PRELIMINARY FEASIBILITY STUDY

EAST CENTRAL WATER CONSERVANCY DISTRICT

presented to

Montana Water Resources Board

by

TAP INC

ECONOMIC CONSULTANTS

with
engineering assistance
from

MORRISON - MAIERLE, INC.
CONSULTING ENGINEERS

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Helena, Montana

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TABLE OF CONTENTS

TABLE OF TABLES

CHAPTER III - IDENTIFICATION OF POTENTIALLY IRRIGABLE LAND, LAND USE, & CURRENT LAND OWNERSHIP

CHAPTER IV - COAL RESOURCES & DEVELOPMENT POTENTIAL

CHAPTER V - WATER SUPPLY AND DEVELOPMENT POTENTIAL

CHAPTER V (Cont.)

CHAPTER VI - AREA BENEFITS - DIRECT & INDIRECT

CHAPTER VI (Cont.)

CHAPTER VII - PRELIMINARY ANALYSIS OF PROPOSED SYSTEMS FEASIBILITY

CHAPTER VII (Cont.)

TABLE OF FIGURES

CHAPTER IV (Cont.)

CHAPTER V - WATER SUPPLY AND DEVELOPMENT POTENTIAL

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Douglas G. Smith, Director
Wilbur White, Vice-Chairman and Secretary
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SUMMARY

The Study

As a result of provisions within the Montana Water Conservancy Law of 1969, study requests by applicant agencies, and subsequent actions by the Montana Water Resources Board, this preliminary study of the proposed East Central Water Conservancy District was undertaken. The major tasks of this study include: (1) preliminary estimates as to the costs of contemplated works, maintenance and operation, (2) tentative decisions as to the feasibility of conservancy district establishment and (3) recommended conservancy district boundaries, so as to maximize the feasibility and desirability of district formation.

This preliminary study of the proposed East Central Conservancy District, including Garfield, McCone and portions of Dawson and Richland Counties, was carefully designed to satisfactorily achieve the above tasks. The basic project works contemplated in this study involve the pumping of Fort Peck water to the lands of the area for a wide-range of beneficial use. In-depth examination and analysis of specific individual works or projects for full development of the area's total surface water resources was not part of this study, but undoubtedly warrants further consideration (on the basis of detailed information contained in this study). The study's basic organization and a brief description and summary of its major findings are included below.

The research effort, as contained in this publication, begins with a broad overview of the area's primary descriptive characteristics (Chapter II). Characteristics such as population, climate and transportation are examined under general characteristics. Also, a brief analysis of the area's overall economic profile, and specifically its agricultural profile, is presented. Major conclusions from the examination of descriptive characteristics include: (1) a low level, stagnant or declining, general economy which is largely based on agriculture and (2) a relatively extensive and unstable agriculture based almost entirely upon dryland farming operations.

A major undertaking of this study was the identification of current land use and land ownership, throughout the study area. Based on previous research findings and actual on-site field reconnaissance surveys, the potentially irrigable land areas were then delineated. All data relating to current land use, land ownership and potentially irrigable land are contained in Chapter III of the report and Section I of the accompanying Detailed Map Assembly. Data compiled for the

potentially irrigable lands are not only mapped, but are listed in detail, by township, in the Enumerative Data tables following the text portion of Chapter III. Replacement acreages, by township, for present cropland and rangeland are indicated, as well as land classification.

The potential for active development of the area's coal resources, particularly in McCone County, was studied in Chapter IV. The possibility certainly exists, especially with proper planning and unified community promotion, that the development of those resources will become a reality. Coal development would result in valuable additional employment, tax base potential and make a substantial direct contribution, as a user of water, to effective and meaningful water development in the area.

Benefits, both direct and indirect, which would likely accrue to the area, as a result of total water development are examined in Chapter VI. Several specific areas of benefit are mentioned, including those associated with the agricultural,municipal, industrial, and recreational uses of water. A major, and possibly crucial, source of benefits to the entire proposed system is the development of available coal resources and the associated potential revenue from industrial water use. The most significant benefit, which could be realized as a result of total development of the area's water resources, is a generally stimulating and stabilizing effect on the area economy. Additionally, a partial irrigated agriculture would provide added management flexibility, as well as opportunities for improved utilization of existing resources. The direct benefit to agricultural units of the area would be very significant.

Preliminary estimates as to the construction cost of the contemplated systems, including operation and maintenance costs, are outlined in detail in Chapter V. The detail of the presentation includes not only physical and financial features, but also an excellent description of the area's water resources and their potential for development. Six water transport systems are studied and analyzed. Two of these proposed systems are located in McCone-Dawson-Richland Counties and four are located in Garfield County. Those portions of the previously delineated potentially irrigable lands, which could actually be served by the proposed systems, are indicated, by township, in Chapter VI. Visual details of the systems, as they relate to the potentially irrigable lands, current land use and land ownership are to be found in Section II of the Detailed Map Assembly.

Section III of the Detailed Map Assembly contains mapped information regarding present irrigated lands of the

study area.

Based upon the information assembled in Chapters I through VI, the remaining portions of the text examine the feasibility of: (1) the proposed systems and (2) the establishment of a water conservancy district in the study area.

On the basis of this preliminary study, it has been concluded that both of the proposed systems in McCone-Dawson-Richland Counties merit additional detailed analysis. Also, one of the proposed systems within Garfield County should, it is believed, be examined further. It is judged that such additional detailed study is required to more precisely estimate the costs and associated benefits which are necessary to make a final judgment as to feasibility of the various systems.

The ground work has also been laid in this study which would serve as a foundation for the assessment, on a detailed basis, of numerous other water development projects for the area, projects other than the six contained in this preliminary study. There are probably many water development projects, which could be developed as successful projects, in the area, which this study does not examine. This study does, however, provide a data base for identification of such potential projects and also provides considerable basic data which will be of tremendous value in testing the feasibility of such projects, when they are identified.

It is the strongly positive recommendation of this study, that the local people carefully consider the desirability of taking the next steps required for formation of a conservancy district. The vast amount of data presented in this study strongly suggests that a conservancy district is feasible and would be desirable for the areas's total development.

Preliminarily recommended boundaries of such a district are included in Chapter VIII, although many questions on conservancy district boundaries need to be examined in further research efforts. Undoubtedly, the next action concerning the formation of a water conservancy district or request for additional detailed study is the responsibility of the local area people. The data and information contained in this study provides a valuable input base toward initiating such actions and decisions.

Conclusions

1. The Conservancy District Law provides an opportunity

for local active involvement in water resources development. The conservancy district, as an entity, can and should foster, organize and promote all types of water development projects within the area.

2. The economy of the study area is generally stagnant or declining and is in definite need of revitalization. The injection of an irrigated agriculture into the area's economy would provide desired stability and added flexibility in resource use.

3. The study area, of Garfield, McCone, and portions of Richland and Dawson Counties, possesses approximately 231,000 acres of potentially irrigable land. However, the potentially irrigable lands which have been delineated from the area, for the most part, are somewhat scattered and non-adjacent in nature. Relatively rough and broken terrain makes it difficult to efficiently reach all the identified potentially irrigable lands.

4. Assuming that most new irrigated acreages would be primarily added onto existing units under excellent management, significant benefits would accrue to the area's agricultural economy. Agricultural diversification, stability, and improved flexibility of resource use would result.

5. Assuming sufficient quantity and quality of available water, direct benefits would result from municipal, recreational and industrial uses. The successful development of the area's coal resources, and the associated industrial water sale, could ultimately supply the key to the availability of reasonably priced irrigation water.

6. Total development of the area's water resource potential is critical. Any reference to specific system costs included in this study, must be interpreted in perspective with total development potential. The benefits associated with agricultural, municipal, recreational and industrial uses must all be analyzed and carefully weighed.

7. On the basis of all preliminary cost and benefit information, it is judged that the study area has significant water development potential - even beyond the works specified for examination in the scope of this particular study. A conservancy district is judged to be desirable for the organization of area water development, with or without

implementation of these or any Fort Peck pumping plans.

8. Preliminary estimates of system costs indicate that three of the six systems examined deserve detailed consideration. Systems which would serve approximately 143,000 acres were thoroughly examined - of these, three systems which would serve just over 94,000 acres in McCone, Dawson and Richland Counties were judged to be feasible on a preliminary basis. A detailed study may, however, render new information on system feasibility. On a detailed basis, some systems, not before examined in depth, may prove to be of a definitely feasible nature.

9. It is strongly recommended that the local area people initiate the necessary series of actions, which are required to form a conservancy district. Such a conservancy district, both in terms of land area encompassed and designated function, should be founded on the basis of actively fostering, organizing and promoting all types of beneficial area water development.

CHAPTER I

THE CONSERVANCY DISTRICT LAW & GENERATION OF THE RESEARCH PROBLEM

THE CONSERVANCY DISTRICT LAW & GENERATION OF THE RESEARCH PROBLEM

A. INTRODUCTION

The Water Conservancy Act, as contained in the Revised Codes of Montana, 1947, hereafter in this report referred to as the Conservancy District Law, is an act providing for the conservation and development of water and land resources of Montana through the creation of conservancy districts.

This section of the study is designed to accomplish two distinct purposes. The first purpose is to briefly review the provisions for the establishment and operation of a conservancy district as provided for in the Conservancy District Law. In no way, should this be construed to be an official, legal opinion as to the contents and provisions of the law. Rather it is written in an attempt to provide a thumbnail sketch as to: (1) what a conservancy district is, (2) the purpose of a district, (3) the steps provided for the formation of a district, and (4) the general provisions for operation of a district should it be organized.

Appendix A of this report contains a copy of the complete law as it is contained in Sections 89-3401 through 89-3449, inclusive, of the Revised Codes of Montana, 1947. Details on any of the points referred to in this outline concerning the exact wording and content of the law can thus be found in Appendix A. Full meaning and interpretation can be achieved by only reading the law in its complete text.

The second purpose of this section is to relate the preliminary feasibility study effort specifically to the provisions within the Conservancy District Law, which provides for the conducting of such a preliminary feasibility study as the first necessary step leading toward formation of a district.

B. PURPOSES OF A CONSERVANCY DISTRICT

A conservancy district, as provided for in the Conservancy District Law, is a political subdivision of the State of Montana, as well as a public corporation. The law provides that the conservancy district may consist of the whole or parts of one or more counties of the state of Montana. This provides the opportunity for a conservancy district to follow boundaries other than the political subdivision boundaries of a county. A conservancy district may have

legal boundaries along other meaningful divisions such as drainage areas or major trade areas of the state.

The Conservancy District Law provides, in part, an outline of the purposes of a conservancy district. The major stated purpose is to aid in the beneficial development of the water resources of the state of Montana to the betterment of the people of the individual areas and thus the entire state of Montana (Sections 89-3401 through 89-3402).

As referred to above in the Conservancy District Law, the purposes of a conservancy district are provided for as follows (Section 89-3402):

> "The purpose of this act is to enable the formation of conservancy districts, comprised of area in one or more counties to promote the following purposes:
>
> (1) prevent and control floods, erosion and sedimentation;
>
> (2) provide for regulation of stream flows and lake levels;
>
> (3) improve drainage and to reclaim wet or overflowed lands;
>
> (4) promote recreation;
>
> (5) develop and conserve water resources and related lands, forest, fish and wildlife resources;
>
> (6) further provide for the conservation, development, and utilization of land and water for beneficial uses including, but not limited to, domestic water supply, fish, industrial water supply, irrigation, livestock water supply, municipal water supply, recreation, and wildlife."

C. PRELIMINARY STEPS NECESSARY IN THE FORMATION OF A CONSERVANCY DISTRICT

The Conservancy District Law outlines the steps provided for, within the law, as necessary steps in the formation of a conservancy district (Sections 89-3404 through 89-3407).

The Preliminary Feasibility Study

The first step required in the formation of a district is the filing of a written request, by the applicants, to the Montana Water Resources Board for the conducting of a preliminary survey for a proposed district.

An alternative is provided for in the law whereby the Montana Water Resources Board may initiate a preliminary survey without any prior request. This, then, makes it possible for the Montana Water Resources Board to combine requests and designate the general study area to be covered in a preliminary study. The preliminary study may be the result of either the filing of a request by an applicant or through initiation of a preliminary study by the Montana Water Resources Board, or both.

The second step required in the formation of a district is for the Montana Water Resources Board to acknowledge receipt of such a request, at which time the Board may proceed to examine the request in relationship to the state water plan and then conduct a preliminary feasibility study. The main tasks of assessing preliminary feasibility are to be found in Section 89-3405 of the Conservancy District Law. These tasks are discussed later in the current chapter in relationship to this study.

The Public Hearing

Following the completion of the preliminary survey by the Montana Water Resources Board, the study is supplied to the applicant and others specified in the law for study and review. The Conservancy District Law, then, provides for a public hearing to be held by the Montana Water Resources Board, at the request of any or all of the applicants.

The Detailed Feasibility Study

Following the hearing, and upon request of any or all of the applicants, there are provisions for the Montana Water Resources Board to prepare a detailed feasibility study concerning the proposed district, assuming the Board has concluded that the proposed district is feasible, desirable, and consistent with the state water plan. This detailed feasibility study is to contain information and the necessary data required to test the ultimate feasibility of the establishment of the proposed district. The law provides, in part, for the major items to be covered in such a detailed feasibility study in Section 89-3407 of the Conservancy District Law.

D. VOTING AND ORGANIZATIONAL STEPS REQUIRED TO ESTABLISH A CONSERVANCY DISTRICT

Organization Procedure and Original Signed Petition

The Conservancy District Law provides in part for the steps necessary in the actual establishment or organization of a conservancy district. Section 89-3408 of the Conservancy District Law is as follows:

> "If in the opinion of the Water Board the feasibility study shows that a district is feasible and consistent with the state water plan, the procedure for organization is:
>
> (1) the Water Board shall file a petition requesting organization with the court;
>
> (2) the petition shall:
>
> (a) state the name of the proposed district;
>
> (b) give a legal description of the boundaries of the proposed district, excluding therefrom lands which would receive no direct or indirect benefits from the proposed district;
>
> (c) describe the purposes of the district;
>
> (d) describe the works;
>
> (f) list the taxable valuation of real property in the proposed district, which must be one hundred thousand dollars ($100,000) or more;
>
> (g) describe the means of repaying capital costs;
>
> (h) propose the persons who should be represented and the number of directors.
>
> (3) The petition shall be signed by owners of at least fifty-one percent (51%) of the land outside the limits of an incorporated municipality, and not fewer than five percent (5%) or one hundred (100), whichever is the lesser, of the persons who would qualify as electors within an incorporated municipality."

The provisions in Section 89-3408 of the Conservancy District Law, as printed above, clearly state that the owners of at least fifty-one percent (51%) of all of the land outside the limits of an incorporated municipality must sign the petition for the formation of a district, before other steps toward organization of a district can proceed. In addition, not fewer than five percent (5%) or one hundred (100), whichever is lesser, of the persons who qualify as electors within an incorporated municipality must also sign such a petition. The signing of such a petition is primarily tied, not to the number of land owners, but to the land owners and the total quantity of land owned by each. Fifty-one percent (51%) of the land, not fifty-one percent (51%) of the land owners, must be represented on the original petition.

Election Requirements

The conservancy district law deals with the provisions for the court to arrange for an election, which is required for the organization of a district (Section 89-3409). This election is held to secure the vote of the electors, as to their desire to form a conservancy district. The court is defined, in part, in Section 89-3403 of the Conservancy District Law as follows:

> (4) "'Court' means the district court of the judicial district in which the largest portion of the taxable valuation of real property of the proposed district is located and within the county in which the largest portion of the taxable valuation of real property of the proposed district is located within the judicial district."

The Conservancy District Law also states, in part, the election requirements for formation of a conservancy district (Section 89-3409):

> (2) "In order for the district to be organized, fifty-one percent (51%) or more of the eligible electors must vote in the election, and a majority of those voting must vote in favor of organization."

The election which is required for the organization of a district has distinctly different requirements than those provided for in the petition required to initiate the action to set up the election. The voting requirement for a district to be organized requires that fifty-one percent (51%) or more of the eligible voters must vote in favor of

the formation of a district. Each elector has one vote and the quantity of land owned by that elector does not have an effect, except through his single vote. This, it should be noted, is in direct contrast to the requirement for the petition, which is tied primarily to the quantity of land owned by each elector--the exception to this generalization being in the case of electors residing within a municipality.

The Conservancy District Law provides, in part, for the definition or identification of qualified electors (Section 89-3423):

> (1) "Only persons who are taxpayers upon and owners of real property located within the district and whose names appear upon the last completed assessment roll of some county within the district for state, county and school district taxes are electors and shall be entitled to vote in elections, provided that:
>
> (a) an elector need not reside within the district in order to vote;
>
> (b) where a corporation owns taxable real property within the boundaries of the conservancy district, the authorized agent of such corporation shall be entitled to cast a vote on behalf of the corporation;
>
> (c) where land is under contract of sale to a purchaser and the contract is recorded, only the purchaser shall have the right to vote;
>
> (d) guardians, executors, administrators, and trustees of real property within the district shall be entitled to cast the vote for the owner of the land.
>
> (2) When voting, an agent of a corporation (sic) or of co-owners, or a guardian, executor, administrator, trustee, or purchaser under contract of sale, may be required to show his authority by the judges of the election."

Board of Directors

Provisions are also included for the formation of a Board of Directors to serve as a governing body for the corporation or conservancy district (Section 89-3412). The

number to serve on the Board is to be determined by the court and the board members are to be appointed directly by the court. It is provided that there should be at least three, and not more than eleven, board members with staggered terms of office--a full term representing three years. The law provides that vacancies on the Board are to be filled by appointment or re-appointment by the court. The court also sets the date of the first annual meeting and sets the amount of corporate surety bond which each member of the Board of Directors shall furnish, at the expense of the district, conditioned upon his faithful performance of his duty as a director.

Provisions are made for officers and general organization of the directors, as the governing body of the district (Section 89-3413). Additionally, the law outlines, in part, the powers, duties, functions, and responsibilities of the Board of Directors (Section 89-3414).

E. TAXING AND BONDING PROVISIONS FOR A CONSERVANCY DISTRICT

The law provides, in part, for the taxing power and limits of the district (Section 89-3416). Provisions are included for the approval of the electors for a bond issue by the conservancy district (Section 89-3429). These two sections of the law are included below, due to their importance to the questions of bonding and taxation as provided for in the Conservancy District Law.

> "Section 89-3416. (1) To the extent that anticipated revenues from rates, fees, and other charges fixed pursuant to Section 89-3414, subsection (17) will not be sufficient to meet the district's anticipated obligations for annual operation, maintenance, and replacement or depreciation of works, or for payment of the interest and principal on bonded indebtedness, the directors may make an assessment of not more than two (2) mills on all taxable real property in the district for the purpose of fully meeting such obligations.
>
> (2) In addition to the assessment authorized by subsection (1), the directors may annually make an assessment of up to three (3) mills on the taxable real property in the district to pay interest and principal on bonded indebtedness.

(3) The assessments are a lien upon each lot or parcel of land within the district to the extent of the assessment on each.

(4) All assessments have the same force and effect as other liens for taxes and their collection shall be enforced in the way provided for enforcement of liens for county taxes. Assessments, if not paid, become delinquent at the same time as county taxes.

(5) Except as provided for in Section 89-3429, approval of the electors is not required for the making of these assessments."

"Section 89-3429. (1) For a bond issue to be approved, forty (40) percent of the qualified electors must vote thereon, and sixty (60) percent of those voting must approve the issue.

(2) Approval of the bond issue shall authorize the directors to make assessments as provided in Section 89-3416 necessary to pay the principal and interest on bonds issued.

(3) The directors shall enter the results of the election in their records.

(4) If otherwise fairly conducted, no irregularities or informalities shall invalidate the election.

(5) Bonds for more than one purpose may be submitted to the electors as a single proposition."

The provisions for taxing, as included in the Conservancy District Law, provide that the directors of the district may annually make two assessments. These assessments may total five (5) mills on all taxable real property in the district.

The first assessment provided for in the Conservancy District Law is to meet obligations in excess of anticipated revenues for annual operation, maintenance, replacement or depreciation of works, or for payment of interest and principal on bonded indebtedness. This can be for a maximum of two (2) mills.

The second provision for taxation in the Conservancy District Law provides that the directors can annually make an assessment of up to three (3) mills to pay interest and principal on bonded indebtedness. The law provides that the directors are required to give notice of a public budget hearing, which among other things, sets the assessments for the next year.

Section 89-3429, as included above, also provides for an approval of the qualified electors for a bond issue to be made on behalf of the conservancy district. This section provides that at least forty percent (40%) of the qualified electors must vote in an election to approve a bond issue by the conservancy district, with at least sixty percent (60%) of those voting approving the issue.

Provisions of the Conservancy District Law are included for certain other budget and fiscal matters in relationship to the Board of Directors and the treasurer of each county of the established conservancy district (Sections 89-3417 through 89-3419, inclusive).

F. OTHER OPERATIONAL PROVISIONS OF THE LAW

Provisions are also made for the following matters:

1. District cooperation with other organizations including federal organizations and programs (Section 89-3415).

2. Powers of the right of eminent domain, as related to the conservancy district (Section 89-3420).

3. Directors' responsibility to report activities directly to the Court and Montana Water Resources Board (Section 89-3421).

4. Examination of all financial records of the district by the Montana State Examiner (Section 89-3422).

5. Election procedures after a district is formed (Section 89-3424).

6. Provisions for the challenge of any person who claims the right to vote (Section 89-3425).

7. The combining of conservancy districts (Section 89-3438).

8. Annexation of real property into the district and exclusion of land from the district, which was included in the original district (Sections 89-3439 and 89-3440, respectively).

9. Dissolution of a district, once formed (Sections 89-3442 through 89-3447, inclusive).

10. The position, in part, of the district in regard to the generation and distribution of electric energy as follows (Section 89-3448):

> "No power to generate, distribute or sell electric energy. Nothing in this act shall be construed to grant to the district the power to generate, distribute or sell electric energy."

11. The conservancy district's relationship to other specific agencies (Section 89-3449).

12. Intent of the legislature in the event that any part of the act is determined invalid (Section 89-3450).

G. GENERATION OF THIS PRELIMINARY FEASIBILITY STUDY -- THE RESEARCH PROBLEM

The Application

The first step required in the formation of a conservancy district, as stated earlier, is either (1) the filing of a request to the Montana Water Resources Board, by the applicant for a preliminary survey for the proposed district; or (2) the initiation of a preliminary survey by the Montana Water Resources Board without formal public request.

Applicants are defined, in part, by the law as follows (Section 89-3403):

> "'Applicants' mean any persons residing within the boundaries of the proposed district making a request for a study of the feasibility of forming a conservancy district."

The present study resulted from the initial filing of an application to the Montana Water Resources Board for a preliminary survey of the proposed conservancy district, by the McCone County Soil and Water Conservation District. This original application was signed by the following

individuals on behalf of the applicant agency: Milo Hilstad, Stanley Robbins, Robert Brown, Wilbur Eggebrecht, Eugene Schuld, Kenton Larson, and Lyle Quick. The application or request for a preliminary survey was filed with the Montana Water Resources Board, by the applicant, in March of 1970.

The Contract for Preliminary Feasibility Study

As a result of the application by the McCone County Soil and Water Conservation District and subsequent deliberation of the Montana Water Resources Board, T.A.P., Inc. of Bozeman, Montana, was awarded a contract to conduct the preliminary feasibility study for this proposed district, to be known as the East Central Water Conservancy District.

This publication, as well as the study and research leading to it, was generated as a direct result of that contract between T.A.P., Inc. and the Montana Water Resources Board.

The law provides that the request to the Montana Water Resources Board shall contain three items:

(1) a general description of the proposed boundaries of the districts;

(2) a statement as to the purpose or purposes of the districts;

(3) a list of the works contemplated.

The general proposed boundaries of the preliminary study as outlined to the research team by the Montana Water Resources Board, are all or part of those portions of McCone and Garfield Counties which fall within the general drainage area along the Redwater River to a point where the Redwater River enters the Missouri River.

The applicant specified that the major purpose or purposes of the district would be to provide for water development within the area to supply water for agricultural and municipal purposes, as well as water for possible industrial and other developments in the area.

The brief description of works contemplated, as contained in the preliminary survey request, was to consider on a preliminary feasibility basis, the taking of water from Fort Peck Reservoir and the distribution of such water for beneficial uses within the proposed conservancy district area.

The Job of the Preliminary Feasibility Study

The law provides for the Montana Water Resources Board to examine the request by the applicant in relationship to the state water plan and also to conduct a preliminary feasibility study as to the formation of such a district (Section 89-3405). The law generally provides for the main tasks to be accomplished in assessing preliminary feasibility. Generally, these tasks are:

(1) to arrive at preliminary estimates as to the costs of works, maintenance and operation of proposed projects;

(2) reach tentative decisions, on a preliminary basis, as to the feasibility of the establishment of a conservancy district;

(3) determine possible sources of financing;

(4) adjust the boundary of the district proposed to improve the feasibility and desirability of the conservancy district.

The specific research undertaken to assess the preliminary feasibility of the establishment of a conservancy district in East Central Montana is presented in this study. The study involves a complete description and analysis of the study area.

Further, a considerable amount of detailed work has been conducted to identify the potentially irrigable lands, land ownership, and current land use within the study area.

It has also become apparent, throughout the development of the study, that the industrial use of water through development of the coal resources of the area, may be extremely important to the ultimate feasibility of the district. The study, therefore, contains a review of the possible industrial uses of water related to development of the area's coal resources. Another major study effort has been to assess, on a preliminary feasibility basis, the area's water resources and their total development potential. The major works which have been considered, in the preliminary feasibility sense, are works which would be designed to supply water from Fort Peck Reservoir to the study area. The concept of total area water development is emphasized.

The research job was, then, to assess the benefits of both a direct and indirect nature which could accrue to the area's residents as a result of increased water development. These increased benefits are compared with cost information contained in the study to make a preliminary analysis and judgement as to the likely feasibility of conservancy district establishment within the proposed study area.

The final section of the report describes the conservancy district in terms of its possible functions and boundaries.

The material is presented in such a form that the reader should, independently, be able to determine initial feasibility conservancy district establishment. Assessment may, then, also be made regarding desirability in terms of compatibility with the state water plan and compatibility with development plans of the area.

The preliminary feasibility study, as called for in the law and as contained in this report, attempts to accomplish at least three very important tasks for the people of the area, the Montana Water Resources Board and others:

(1) The first of these is to organize and assemble data relative to testing, on a preliminary feasibility basis, the desirability of pursuing further the establishment of a water conservancy district. Such a district, within the study area, should be examined in relationship to the total development of water resources for the betterment of the area, its people, and the state of Montana.

(2) Test, on a preliminary feasibility basis, the desirability or potential feasibility of works contemplated within the proposed conservancy district. In this study, these works are centered primarily on the objective of distributing water from Fort Peck Reservoir into part or all of the study area for beneficial uses.

(3) To provide a background data base and research product which the local people, the Montana Water Resources Board and others can effectively use to determine the desirability of taking the next step in conservancy district establishment, which is the preparation of a detailed feasibility study, as called for in the Conservancy District Law. If a detailed feasibility study is judged to be

desirable, then this preliminary feasibility study will not only provide an extremely valuable input to that study, but will also aid tremendously in providing the specifications and job definitions to be included in that detailed feasibility study.

All of the material which follows in this report is aimed at satisfactorily accomplishing these three basic tasks.

DESCRIPTION OF THE STUDY AREA

A. GENERAL CHARACTERISTICS

Population

The east central Montana conservancy district study area includes Garfield, McCone and the Redwater drainage portions of Richland and Dawson Counties. Due to the general nature of much of the descriptive data available, however, the entire counties of Richland and Dawson are included in the following discussion. Qualifying statements are included, whenever pertinent, in an effort to minimize this variance in geographic area.

The total land area of the four counties is approximately 11,500 square miles, which comprises nearly eight percent of the State's total land area (Figure II-1). Although large in area, these four counties generally do not enjoy many of the traits which bigness often implies. The primary reason is extremely sparse and generally declining population throughout much of the four county area. The respective average population densities, as presented below, provide a very general concept of the relationship between land area and population:

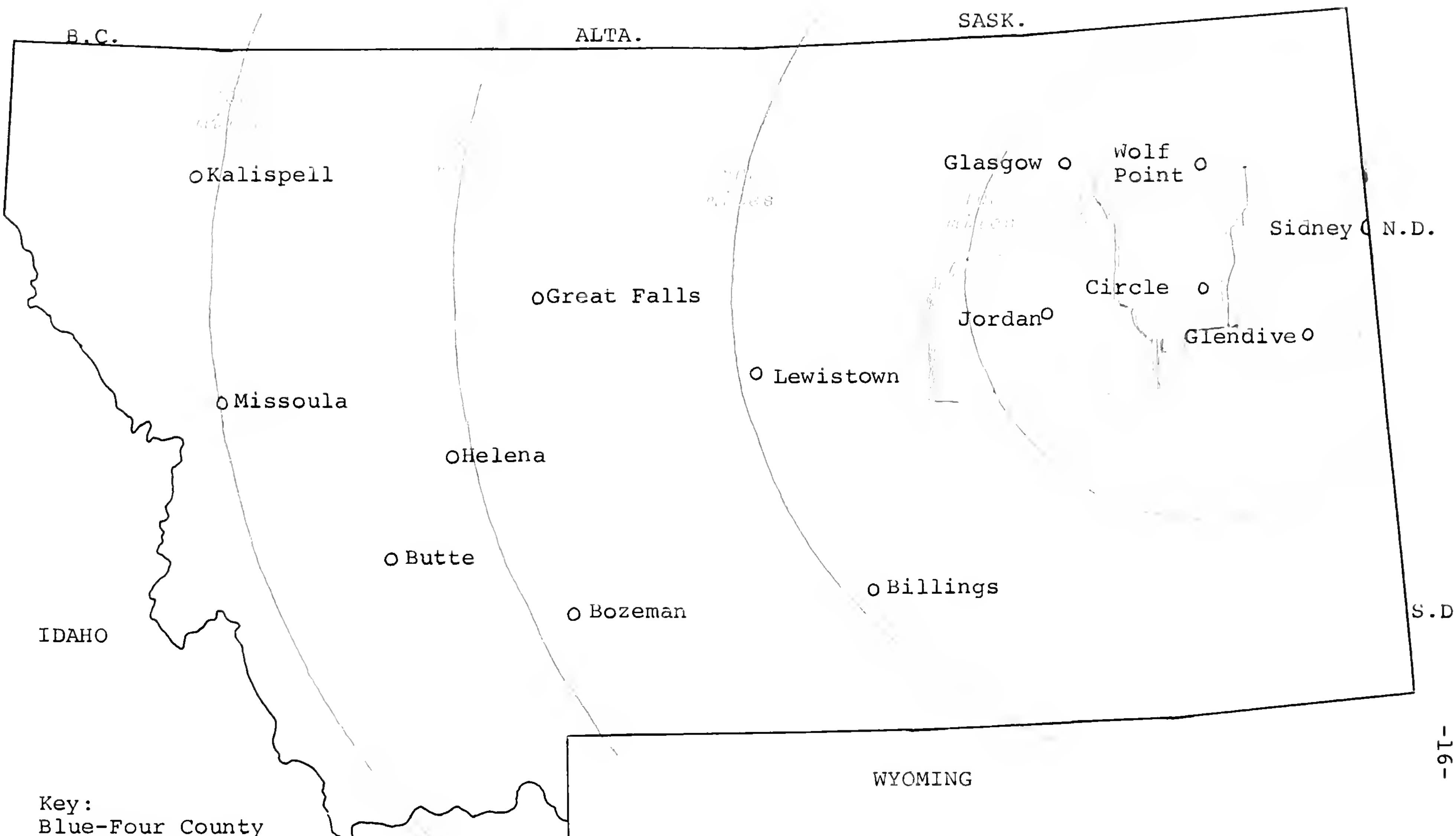
Table II-A
Average Population Densities, 1970*

County	Average Population per Square Mile
Garfield	0.40
McCone	1.10
Richland	4.73
Dawson	4.75

*Source: Computed from 1970 *Census of Population* and 1967 *City-County Data Book*

Although the above densities do reveal a definite sparsity of population, particularly in Garfield and McCone Counties, it must be recognized that, as average densities, these figures do not in any way illustrate the distribution of the population throughout each county. In fact, in the

FIGURE II-1
THE PROPOSED EAST CENTRAL MONTANA
WATER CONSERVANCY DISTRICT STUDY AREA



Key:
Blue-Four County Boundary
Red -Study Area

Source: Adapted from Montana Highway map, Montana Highway Commission, 1970.

Notes: Mileages are computed in relationship to Circle, Montana.

case of each of the four counties within the study area, population tends largely to be concentrated in or near a few relatively small communities lying adjacent to Montana Highway No. 200. For example, when the population of each such major community in each county is subtracted from the county's population, only a minor portion of the total population remains to inhabit the remaining, vast outlying areas (Table II-B).

TABLE II-B
Population Distribution, 1970[1]

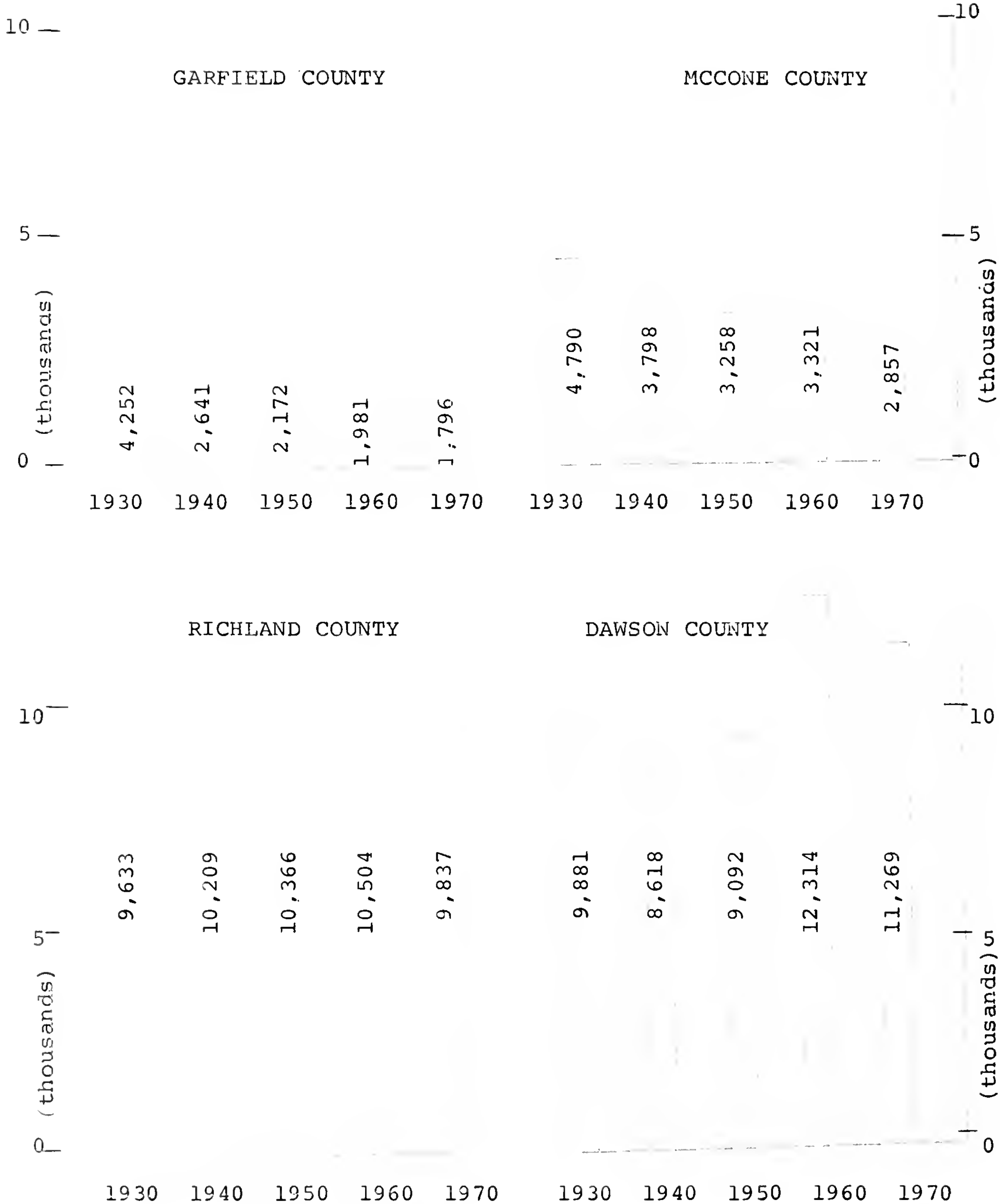
	Population		
County	Total	Major Communities[2]	Outlying Areas
Garfield	1,796	529	1,267
McCone	2,857	2,212	645
Richland	9,837	7,771	2,066
Dawson	11,269	6,694	4,575
TOTAL	25,759	17,206	8,553

[1]Source: 1970 *Census of Population*

[2]Major communities, as defined here, include Jordan (Garfield); Circle, Brockway, Vida (McCone); Sidney, Fairview, Savage, Crane, Lambert (Richland); and Glendive, Richey (Dawson).

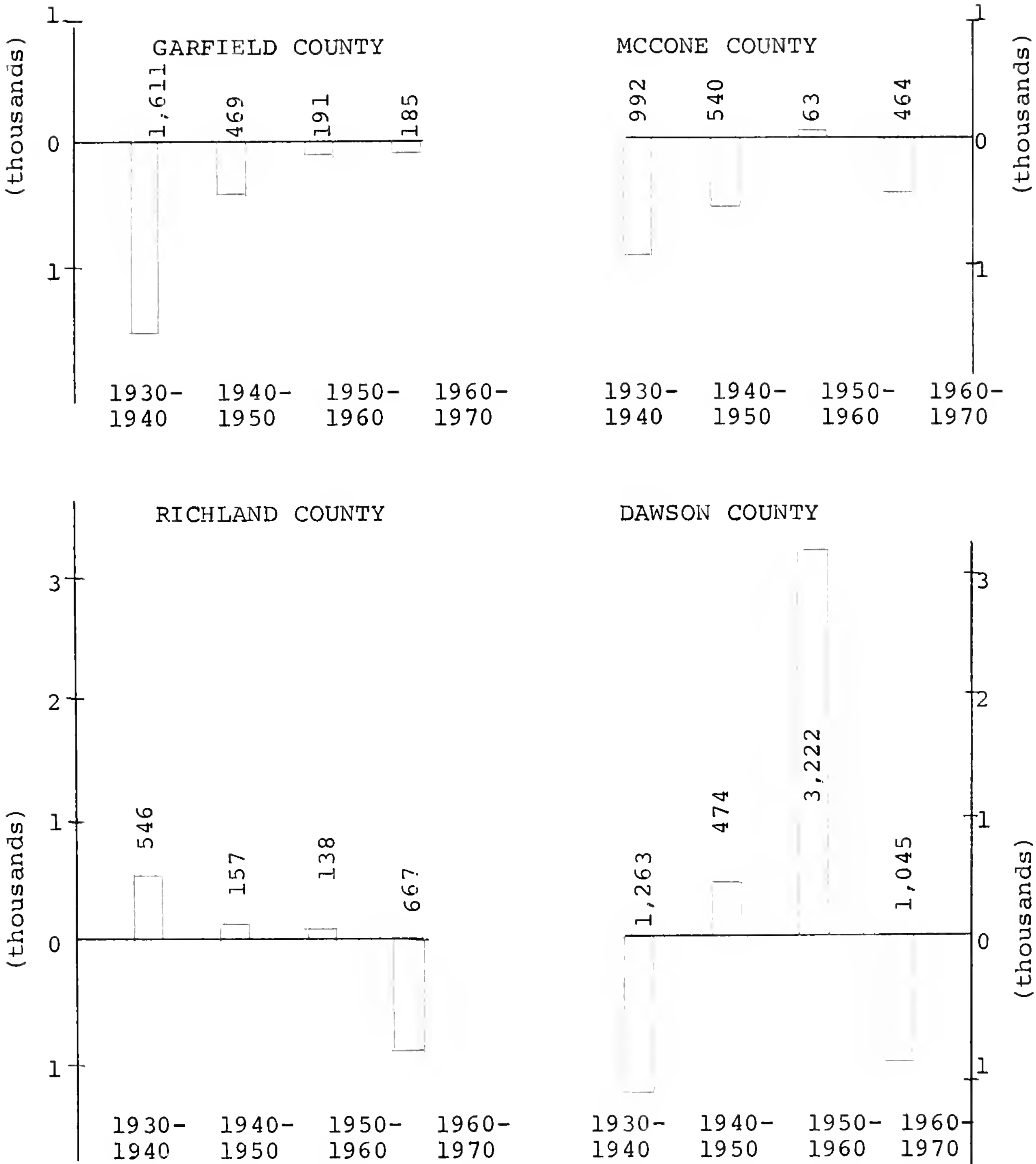
Historic population trends since 1930 indicate a generally declining population for the total four county area (Figure II-2). This fact is particularly obvious for Garfield and McCone Counties. Population trends for the other two counties, however, have not displayed a downward tendency but have instead either remained somewhat stable (Richland) or have generally increased (Dawson). Each of the four counties experienced population losses during the ten year period preceding 1970. Population change data as presented in Figure II-3 further illustrates this fact. Decreasing population was experienced consistently, with one exception, from 1930 to 1970 by both Garfield and McCone Counties -- the one exception being a very small population increase for McCone during the 1950 to 1960 period. Both Richland and Dawson Counties, and particularly

FIGURE II-2
POPULATION, 1930-1970
GARFIELD, MCCONE, RICHLAND & DAWSON COUNTIES*



*Source: *Census of Population*, Bureau of Census, U.S. Dept. of Commerce

FIGURE II-3
POPULATION CHANGES, 1930-1970
GARFIELD, MCCONE, RICHLAND & DAWSON COUNTIES*



*Source: Computed from *Census of Population*, Bureau of the Census U.S. Department of Commerce

the latter, have experienced somewhat less obvious trends. Richland County, however, has exhibited a consistent trend in that its rate of population increase declined constantly between 1930 and 1960 and then actually became a population decrease between 1960 and 1970.

Climate

The east central Montana study area experiences a fairly typical continental-type climate, with warm and occasionally hot summer days and cold winters. Precipitation occurs in the form of both rain and snow with winter season snow build-up in most areas being kept to a minimum by prevailing winds. In combination with summer precipitation, particularly during the latter part of the growing season, electrical storms accompanied by thunder and lightning are not uncommon, with occasional severe hail and sleet storms.

Generally speaking, annual precipitation over the four county area averages from 10 to 15 inches, the majority of which falls during the growing season. The frost free period, as measured at each of the four counties' stations, is usually between 100 and 140 days in duration (See Table II-C). Additional representative data, collected over a thirty year period, indicates that, based upon the computed mean distributions of precipitation for each of two area stations (Jordan and Glendive), the largest concentrations of growing season precipitation occur during a six week period.[1] This six week period includes the last three weeks of May and the first three weeks of June. Amounts of precipitation over the remaining weeks of the growing season have been generally and somewhat uniformly lower than for the previously mentioned six week period.

Trade Centers

As in most regions where population is sparse, the people of east central Montana are quite willing, and in most cases, required to travel relatively long distances to reach even minor trading centers. As a result, the trade centers for various sections of the study area often are located outside the county boundaries. Such a relationship exists between north Garfield and McCone Counties and the Hi-Line communities of Glasgow, Poplar and Wolf Point. Other area trading centers include Jordan, Circle, Sidney, Glendive and Miles City.

---

[1]Source: *Probability of Selected Precipitation Amounts in the Western Region of the United States*, Agricultural Experiment Station, University of Nevada, 1967.

TABLE II-C

PRECIPITATION & NUMBER OF DAYS BETWEEN FREEZING TEMPERATURES - 1966, 1967[1]

County & Station	Annual (inches)			Growing Season April through September (inches)			Frost Free Period[3] (days)		
	1966	1967	Normal[2]	1966	1967	Normal[2]	1966	1967	Average[4]
Garfield Jordan	11.99	14.51	10.31	9.44	11.25	7.81	95	136	106
McCone Vida	19.20	17.89	15.24	16.15	12.69	10.81	145	138	NA[5]
Richland Savage	10.03	13.87	13.41	8.58	10.96	10.62	125	137	131
Dawson Glendive	10.88	14.22	12.73	8.58	11.11	9.91	155	138	139

[1]Source: *Montana Agricultural Statistics*, December, 1968.

[2]Normal for period 1931-1960.

[3]Number of days of between dates of temperature of 32 degrees, last in spring and first in fall.

[4]Average of all reporting stations.

[5]Average based on comparable data not available.

In general, all population centers within the study area suffer from relative isolation with respect to the State's major trading centers -- being in most instances, no closer than from 100 to 250 miles from Billings or Great Falls. Such geographic isolation, in many respects, assists in maintaining the ever-present barriers to economic growth.

Transportation

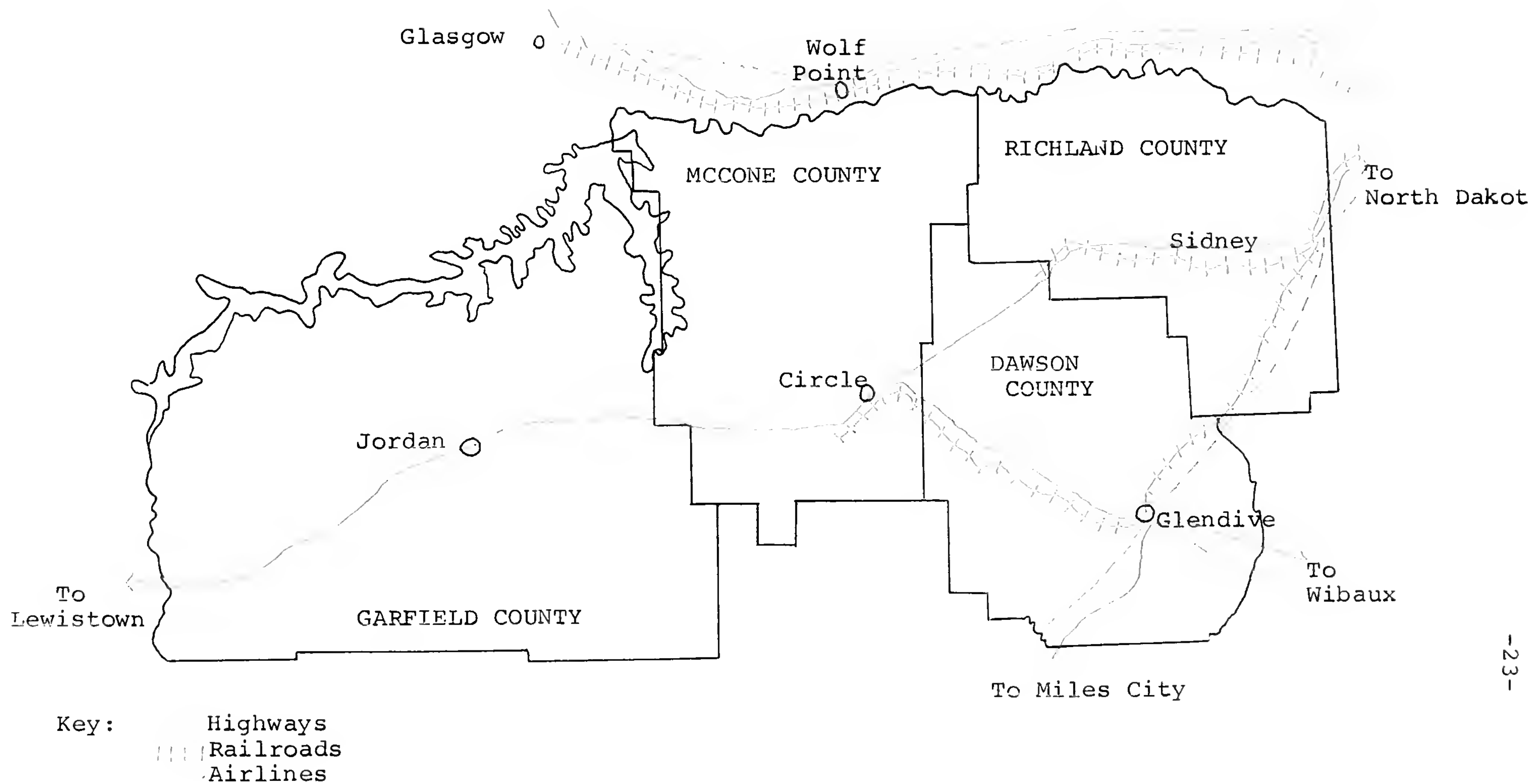
Transporation systems throughout the study area are somewhat meager -- a reflection of the relatively low level of all public services, which is, to a degree, brought about by the extremely sparse population and its accompanying small taxable base. Highway, rail and air services are each, however, available to area residents (Figure II-4).

Primary highway service is provided by: (1) Montana Highway No. 200 which runs east-west through Lewistown, Jordan, Circle and Sidney, and (2) United States Highway No. 2 which runs east-west just to the north of the McCone and Richland County boundaries and serves as an access between Glasgow, Poplar and Wolf Point. Several other secondary highways provide adequate routes to such centers as Miles City and Glendive. Certainly, the automobile is by far the most important form of transportation to people of this area.

Rail freight service is provided to the area by the Burlington-Northern -- previously the Great Northern and Northern Pacific in Montana. Rail passenger service is essentially non-existent. Major rail lines serve nearly all major communities within the area except Jordan in Garfield County. Branch lines currently serve the communities of Circle, Brockway and Richey. The major void within the area's rail network most certainly occurs in Garfield County.

Commercial air service from the east central communities of Sidney, Glendive, Wolf Point and Glasgow has in the past been provided by Frontier Airlines or Apache Airlines. As of November 1, 1970, Frontier Airlines resumed its service of the area, with deHavilland Twin Otter aircraft. Generally, air service in east central Montana is characterized as being of low frequency and having low traffic volume. Commercial air service for most residents of the study area, particularly those of Garfield and McCone Counties, is not easily accessible nor widely used. Private, light planes are often owned by local ranchers and others to

FIGURE II-4
HIGHWAY, RAILROAD & AIR TRANSPORTATION*



*Source: Montana Railway map, McCill-Warner Co., St. Paul, Minnesota.
Montana Highways, Montana State Highway Commission, Helena, 1970.
Air Traffic Schedule, Frontier Airlines, November, 1970.

provide a fast, dependable means of transportation and minimize the effect of relative geographic isolation. A total of 97 aircraft are registered with the Montana Aeronautics Commission, within the four county area -- slightly over seven percent of the State's total registered aircraft. The study area is served by five public airports at Circle, Jordan, Richey, Glendive and Sidney as well as two others on the northern border of the area at Wolf Point and Poplar. There are also at least nine private airports serving various outlying areas of the four counties involved.

General Geology

Sometime, over 60,000,000 years ago, the great sea that had ebbed and waned for eons over eastern Montana disappeared -- at least to present time. During the last years of its existence the sea went through three great advancement -- recession cycles. The advancement cycle (a westward push) resulted in the deposition of great beds of material that eventually became marine shales, known as the Colorado, the Claggett and the Bearpaw. Immediately before and after the period of the Claggett formation, the seas receded and sandy, as well as clay sediments, were deposited on the sea edge. These deposits, known as the Eagle and Judith River formations respectively, consist of sandstone shale layers. During the last recession of the sea, the Fox Hill formation of alternate sandstone and shale layers was deposited.

The sandstone in these three formations contains some water, often highly mineralized and of generally poor quality for both irrigation and domestic uses. In some areas, the Fox Hills sandstones yield fair to good quality water. Also, these formations contain some coal deposits, generally of little economic value, attesting to the existence of swamps with vigorous plant growth along the coastal plains of the receding seas.

During and after this time (late cretacious) large mountains formed largely by folding of the earth's crust, and to some degree by volcanic activity, developed to the west of this area. Erosion from these higher lands resulted in the deposition of great masses of sediment in fresh water lakes and along the streams that once existed in the area. The resultant formations are now known as Lance and the Fort Union, with the Fort Union being the more recent. Both of these formations are interceded sandstones and shales, with shale comprising the largest portion. The

shales of these formations are not marine shales, but much of the source of the sediment was old marine shales. Thus these shales have many of the characteristics, especially with regard to salts, of true marine shales.

These depositions were caused by, and occurred in, fresh waters. Near and in the fresh water lakes and streams of this nearly flat area, vegetative growth was profuse. The thick, extensive coal deposits present in the Fort Union formation were formed from this vegetation. Some idea of the time period involved in this process may be gained if one remembers that mountains, not unsimilar to those we know today, were eroded to nearly level plains and then re-built during this period.

The last great geologic event occurred only a few thousand years ago when huge continental glaciers moved from the north, across the sedimentary plains, to a position just south of the Missouri River. Glaciations had three major influences on the area. It imported materials from far to the north -- many of them very different from those of the area. It dammed rivers causing large fresh water lakes south of its farthermost advance, and, as it receded, it created a typical morain topography.

The imported materials furnished stoney, relatively salt free parent material for soil formation. Soils formed in this material are different and generally more productive than soils formed in the residual plains of the area. Since the last glacial advance was only into the northern part of the area, these soils are restricted to the northern part of McCone County. Glacial lakes formed along the Musselshell and around Jordan and Circle. The soils of these areas formed from deposits in these lakes.

B. OVERALL ECONOMIC PROFILE

Trade Activity

Retail, wholesale and service trade activity for each of the four counties reveals their relative importance in the area economy (Table II-D). In all trade sectors, Garfield and McCone Counties are significantly less important in terms of dollar sales or receipts. Apparent growth within these two counties appears to exist mostly in retail trade, and that only to a small extent. Service trade dropped considerably in Garfield but has increased in McCone County.

TABLE II-D

WHOLESALE, RETAIL & SERVICE TRADE ACTIVITY, 1963 & 1967
GARFIELD, MCCONE, RICHLAND & DAWSON COUNTIES[1]

	Retail				Wholesale				Service			
	1963 Est.	1963 Sales ($1,000)	1967 Est.	1967 Sales ($1,000)	1963 Est.	1963 Sales ($1,000)	1967 Est.	1967 Sales ($1,000)	1963 Est.	1963 Sales ($1,000)	1967 Est.	1967 Sales ($1,000)
Garfield		1,828		2,330		(D)[2]		(D)		252		[illegible]
McCone		2,774		3,030		4,111		3,704		[illegible]		[illegible]
Dawson		16,015		18,716		12,566		19,050		1,694		[illegible]
Richland		19,923		19,048		12,031		11,625		1,424		[illegible]
TOTAL 4 Counties		40,540		43,124		28,708		34,379		[illegible]		[illegible]
4 County Percentage of State		0.4%		3.8%		3.4%		3.2%		3.5%		[illegible]

[1]Source: *1967 Census of Business*, U. S. Department of Commerce, Bureau of the Census

[2]Withheld to avoid disclosure

CHAPTER II

DESCRIPTION OF THE STUDY AREA

Dawson County has exhibited constant growth in all three trade sectors, while Richland has remained somewhat stable -- although slightly decreasing its dollar sales for all trade activities. On the whole, the four county study area has experienced slight growth accompanied by a reasonably stable number of business establishments. As a percent of total state sales, the four county area has lost in all but the retail trade activity. The apparent trend particularly in the more isolated areas, is for decreased wholesaling and servicing, with stable or slightly increasing activity in retail trade to meet the needs of the local people.

Employment and Unemployment

Employment within the study area continues to be largely agricultural -- engaged either directly on farms and ranches or indirectly in agriculturally related businesses. To some degree, particularly in Dawson and Richland Counties, activity in manufacturing and mining does exist. Table II-E presents a breakdown, by selected employment category, of employment in the total four county area.

Employment in retail, wholesale and service trade activities is definitely a major factor in each of the four counties (Table II-F). Total employment in private, non-farm business units is greater than 4,200 people, with Dawson and Richland Counties possessing by far the largest concentrations of such employment (Table II-F). Within the entire area, only one firm exists which employs more than 100 people and only eleven exist which employ more than 50. All of these major employers are in Dawson and Richland Counties. McCone County has four firms which employ between 20 and 50 people and only 22 firms with over five people employed. Garfield has only 13 firms with more than five persons employed and no firms with over 20 employees.

In general, then, employment units within Garfield, McCone, Richland and Dawson Counties are relatively small and are largely concentrated within the basic wholesale, retail and service trade activities. An extremely large portion of the area's employment and nearly 100 percent in certain areas is stimulated either directly or indirectly by functions within the agricultural economy.

Unemployment within the four counties of the study area, generally, has been somewhat less than for the State as a whole. Average monthly unemployment rates for 1969, recently released by the Montana Employment Security Commission, indicate the following: Garfield - 1.47 percent, McCone - 3.11 percent, Richland - 2.58 percent and Dawson 3.55 percent.

TABLE II-E

ESTIMATED EMPLOYMENT OF MAJOR EMPLOYMENT SECTORS - GARFIELD, MCCONE, RICHLAND & DAWSON COUNTIES

County	ESTIMATED EMPLOYMENT					
	Private	Farm[2]		Government[3]		
	Non-Farm[1]	Operators	Hired	State & Local	Federal	Total
Garfield	137	284	122	114	28	685
McCone	312	519	146	170	28	1,175
Richland	1,520	766	239	442	86	3,053
Dawson	2,239	572	137	540	63	3,551
Total 4 Counties	4,208	2,141	644	1,266	205	8,464
Total State	121,612	27,020	10,955	40,500	11,600	211,687
Percent of State	3.5	7.9	5.9	3.1	1.8	4.0

[1] *County Business Patterns*, Montana, 1968.

[2] *Census of Agriculture*, Montana, 1964.

[3] Employment Security Commission, State of Montana, Correspondence, December 16, 1970.

Notes: Farm operators include full owners, part owners, managers and tenants.
Hired farm workers include those working on a regular basis for for 150 days or more per year.

The corresponding 1969 average rate of unemployment for the entire state was 4.48 percent. In the total four county area during 1969, an average of 291 individuals were unemployed, 250 of which were concentrated in Dawson and Richland Counties[1] Detailed unemployment data, by industry and by occupation, is not yet available for the four county area from the Montana Employment Security Commission. Later analysis of such information, when it becomes available, will be of assistance in determining the extent and characteristics of the available labor pool.

TABLE II-F
Private, Non-Farm Employment, 1968*
Garfield, McCone, Richland & Dawson Counties

County	Employment No.	%	Major Industries
Garfield	137	3.26	Retail trade; Services
McCone	312	7.41	Wholesale & retail trade; Services; Manufacturing
Richland	1,520	36.12	Wholesale & retail trade; Services Manufacturing; Finance, insurance and real estate; Contract Construction; Public utilities
Dawson	2,239	53.21	Wholesale & retail trade; Services; Manufacturing; Mining; Public utilities; Contract construction; Finance, insurance & real estate.
TOTAL	4,208	100%	

*Source: *County Business Patterns*, Montana, 1968.

Income

Income earned from all sources by families within the area tends to be distributed in a fashion which is significantly different from the State's average (Table II-G).

In relationship to the State, the study area has a considerably greater percent of its families who earn less than $10,000 per year and a considerably lesser percent who earn $10,000 or more per year. The unusually high concentration of individual families within the $0-4,999 family income category, particularly in Garfield County, is a large contributor to this situation. The data in Table II-G reveals that in 1968 nearly 60 percent of the families in Garfield County had incomes under $5,000 with nearly 53 percent in the same income category in McCone County. These high percent-

[1]Source: Civilian Work Force Data, Montana Employment Security Commission, 1969.

ages are compared to an overall percentage in the State of approximately 38 percent. Certainly this distribution of income is the complex result of a combination of factors, including a general economy which is highly agricultural and currently stagnant or declining.

TABLE II-G
Family Income Distribution by County, 1968*

County	Distribution by Income Group (Pct.)		
	$0-4,999	$5,000-9,999	$10,000 & Over
Garfield	58.5%	28.0%	13.5%
McCone	52.9	33.4	13.7
Richland	47.0	39.9	13.1
Dawson	36.0	45.1	18.9
Four County Average	48.6	36.6	14.8
State	38.3	42.0	19.7

*Source: *Sales Management*, Survey of Buying Power, 1968.

C. AGRICULTURAL PROFILE

Farms and Farm Receipts

As discussed previously, agriculture is a major contributor to those earning their livelihood in Garfield, McCone, Richland and Dawson Counties. These four counties account for nearly eight percent of the State's farms, by

number, with an average size of nearly 3,800 acres compared to about 2,400 for the State (Table II-H). The most extensive farm units, according to size, are located in Garfield County where the average farm size exceeds 8,200 acres.

Farm values throughout the four county area are also quite divergent, ranging from an average of $39,000 per farm in McCone County to $174,000 per farm in Garfield. As would be expected, the extremely large farm values in Garfield County are wholly attributable to the huge farm sizes. For the total area, farm values average $91,000 per farm, which is significantly less than the State's $105,000 per farm average. Examination of average farm values on a per acre basis reveals that farmland is least valuable in Garfield County ($21 per acre) while McCone, Richland and Dawson are somewhat uniform ($36-$39 per acre). The average per acre value for the combined area is $33, which compares to a State average of $43 per acre (Table II-H).

Analysis of agricultural receipts for each of the four counties shows more than $50 million per year in cash receipts -- 9.1 percent of the State's total. By county, Richland leads in total cash receipts, while Garfield possesses the least. Marketing receipts and government payments are also indicated in Table II-H. On a total cash receipts per farm basis, the total area averages $23,000 -- exceeding the State's average by $3,000 per farm. Garfield County leads all others in this category, having an average of $27,000 per farm (Table II-H).

The combined four county area accounts for nearly ten percent of all cash receipts from agriculture in the State. This output is, to a large degree, the result of extensive farming practices covering a large number of acres. Average farm values are generally higher than that for the State -- the primary result of extremely large individual acreages which more than compensate for relatively low per acre values.

Of the total marketing receipts received by farmers and ranchers in Garfield, McCone, Richland and Dawson Counties, a substantial portion is directly attributable to livestock sales. This is particularly true for Garfield County where an average of 80.4 percent of all cash receipts received during the 1958 to 1967 period were from livestock. McCone, Richland and Dawson Counties, however, have tended to have slightly more receipts from crops than from livestock (Figure II-5).

TABLE II-H
FARM NOS., SIZE, VALUE & RECEIPTS
GARFIELD, MCCONE, RICHLAND & DAWSON COUNTIES

	Garfield	McCone	Richland	Dawson	Total Study Area	State	% of State
Farms:[1]							
No. of Farms	284	519	766	572	2,141	27,020	7.9%
Average Size of Farms (in acres)	8,203	2,753	1,585	2,469	3,752	2,437	-
Average Value per Farm	$174,000	$39,000	$63,000	$88,000	$91,000	$105,000	
Average Value per Acre	$21	$37	$39	$36	$33	$43	
Receipts:[2]							
Marketing Receipts[3]	$7,034	$9,654	$14,958	$10,869	$42,514	$487,969	8.7
Government payments[3]	$759	$2,445	$2,708	$2,039	$7,950	$69,098	11.5%
Total Cash Receipts[3] per Farm	$27	$23	$23	$22	$23	$20	--
All Cash Receipts[3]	$7,793	$12,099	$17,666	$12,907	$50,464	$557,067	9.1%

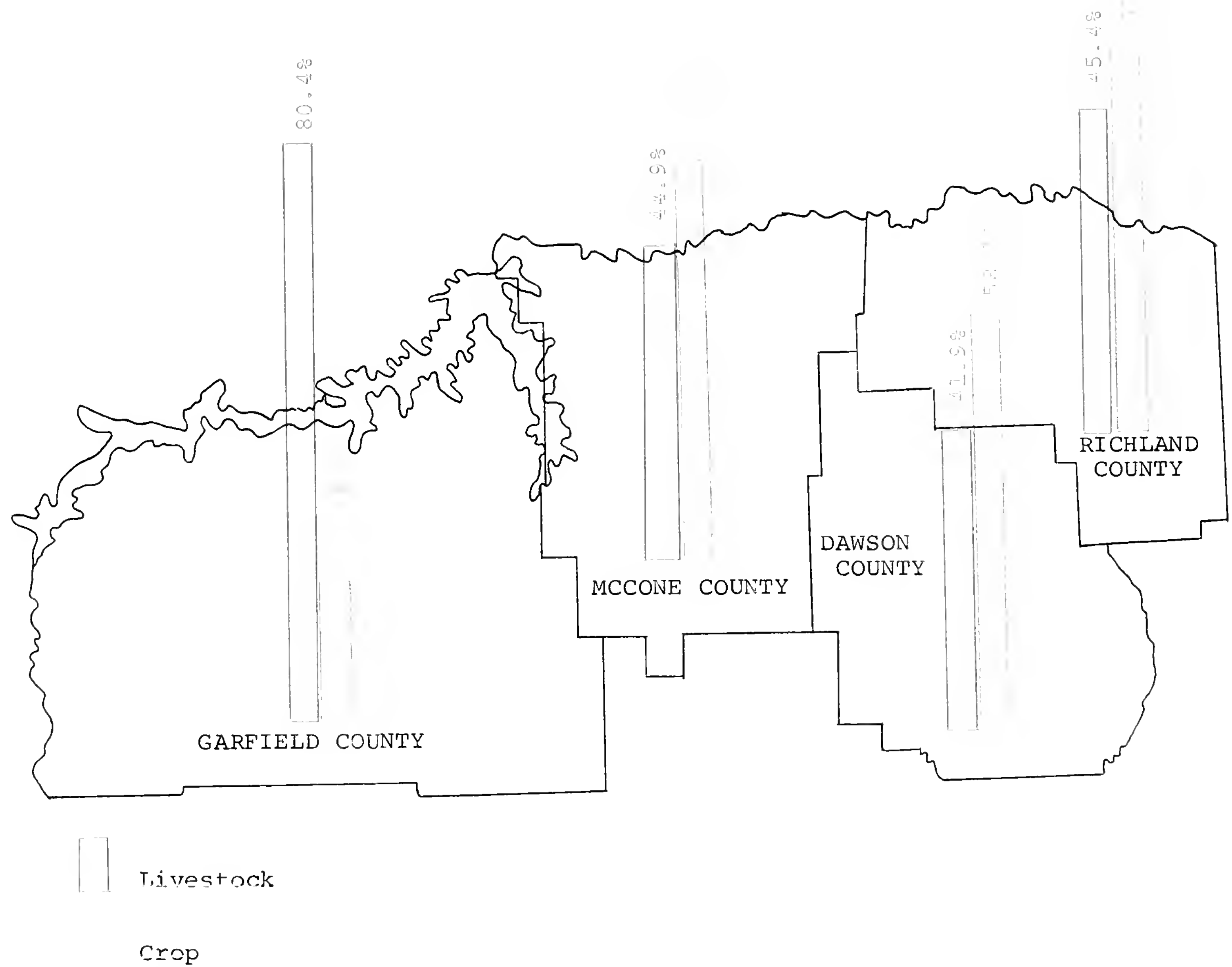
[1] Source: *1964 Census of Agriculture.*

[2] Source: *Montana Agricultural Statistics, 1968.*

[3] ($1,000)

FIGURE II-5

PORTION OF TOTAL CASH RECEIPTS FROM LIVESTOCK & CROP, 1967*



*Source: *Montana Agricultural Statistics*, 1968.

For the combined area, average 1958 to 1967 cash receipts from livestock and crops have maintained a ratio of about one to one, although yearly production may have varied considerably from this trend. There is little doubt that livestock production, including the growing of livestock support crops, is an important part of, not only the area's agricultural economy, but of the area's general economy.

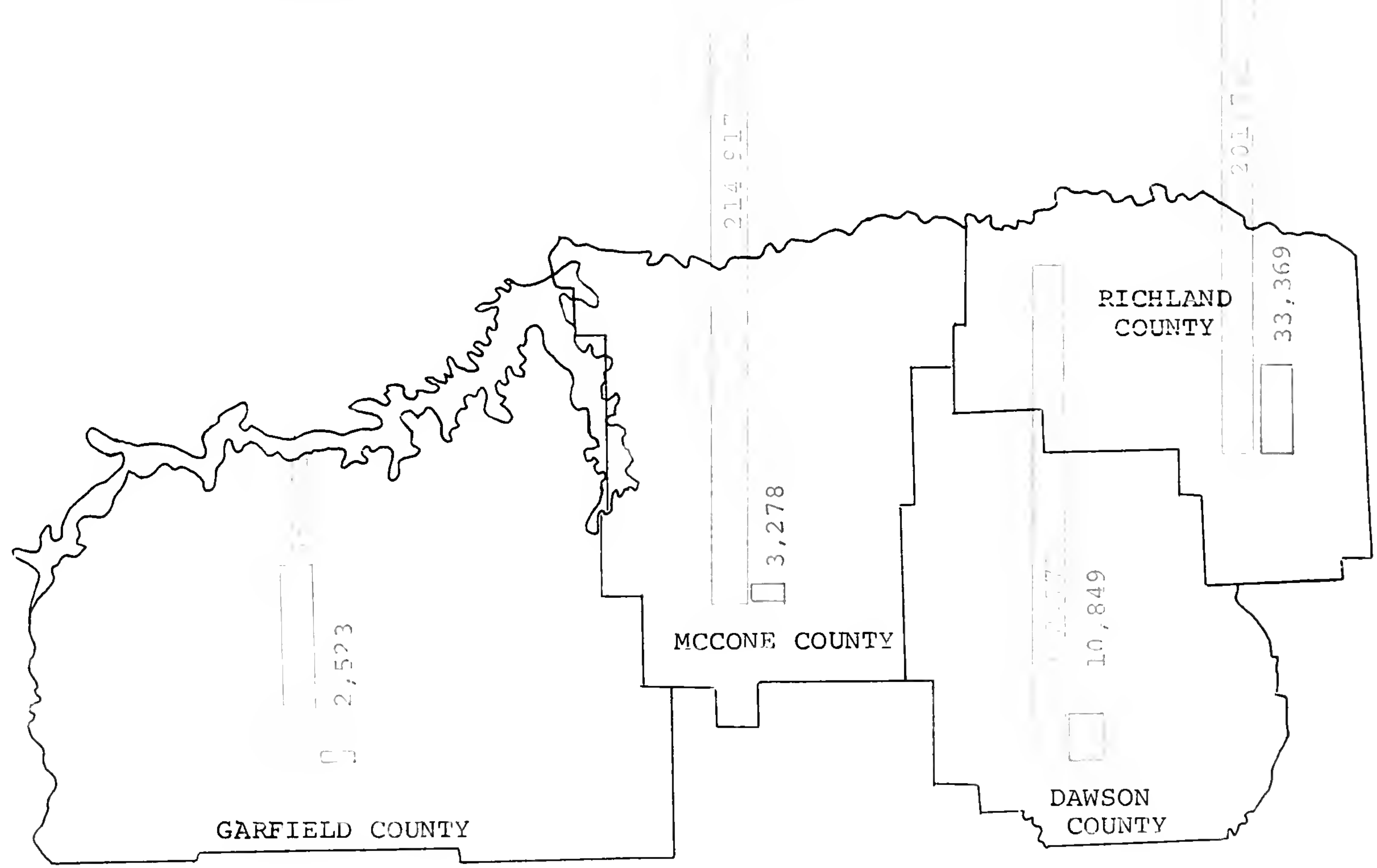
Cropland Harvested

The majority of all cropland within the four county area is dryland, particularly in Garfield and McCone Counties. This is also essentially true in Dawson and Richland, although considerably more irrigation has been developed (Figure II-6).

The reader should be cautioned at this point that the meaning of the term "irrigation", with reference to lands in east central Montana, does not generally fit the commonly accepted meaning of the term. As often referred to in the eastern section of the State, "irrigation" refers to most any type of water diversion to cropland (or in some cases, rangeland) and does not necessarily carry with it any precise indication as to frequency of application. With that qualification in mind, it should be remembered that although many acres are currently classified as irrigated in McCone and Garfield Counties, relatively few are really intensively irrigated and a majority are only exposed to flood water every two to three years. This generalization is made, however, with full recognition that there are some very intensive irrigation developments along the Yellowstone River in Dawson and Richland Counties with similar developments in all the counties along the Missouri River. This question is discussed in detail in Chapter III. Maps showing present irrigation are included later on in the report. Again, it is strongly urged that the attachment of precise significance to the acreages enumerated as presently irrigated be avoided.

Irrigated and dryland crop acreages harvested, including pasture, are identified by crop and by county in Table II-I. In 1966, a total of 778,318 acres of cropland were harvested in the combined county area. Of that total 51,898 or 6.67 percent, were recorded as being irrigated cropland. McCone, Dawson and Richland share approximately equal amounts of total cropland acreage, while Garfield has about one-third that amount. In terms of irrigated acreages harvested, Richland County alone has nearly 33,000 acres which exceeds the total of the remaining three counties. The majority

FIGURE II-6
AVERAGE TOTAL ANNUAL ACRES HARVESTED, 1958-1967
GARFIELD, MCCONE, RICHLAND & DAWSON COUNTIES*



Dryland

Irrigated land

*Source: *Montana Agricultural Statistics*, 1968.

TABLE II-I

CROP ACREAGES HARVESTED & PASTURE, 1967

GARFIELD, MCCONE, DAWSON & RICHLAND COUNTIES[1]

	Garfield		McCone		Dawson		Richland	
	I[2]	D[3]	I	D	I	D	I	D
Winter Wheat	300		--		200		300	
Spring Wheat	--		--		500		2,900	
Durum Wheat	--		--		--		400	
Barley	--		--		400		2,600	
Oats	200		--		300		1,900	
Rye[4]	--		--		--		--	
Flaxseed	--		--		--		--	
All Hay	2,000		3,800		5,200		10,200	
Corn Silage	--		100		2,500		3,900	
Sugar Beets	--		--		3,400		10,500	
Potatoes	--		--		192		106	
Total Acres	2,500		3,900		12,692		32,806	
Total Cropland Harvested	84,700		238,200		212,591		783,167	
Pasture[5]	2,210,410		971,707		1,022,849		242,167	

[1]Source: *Montana Agricultural Statistics, 1968*

[2]Irrigated acreage

[3]Dryland acreage

[4]Principally not irrigated

[5]Source: *1964 Census of Agriculture*, Bureau of Census, Dept. of Commerce

of all cropland, however, remains in dryland applications.

The major crops grown in the area include winter wheat, spring wheat, durum wheat, barley, oats, rye, flaxseed, hay, corn silage, sugar beets, potatoes and pasture. Not all crops, however, are grown in each county -- rye, sugar beets and potatoes are generally harvested only in Dawson and Richland. Dawson County leads in winter wheat production, while McCone harvests the greatest quantity of spring wheat. Durum wheat and barley production is concentrated primarily in McCone, Dawson and Richland Counties. Flaxseed and rye account for only minimal acreages. Oats and hay are grown in about equal proportions throughout the four counties, while pasture lands are largely concentrated in Garfield and to a lesser degree in McCone and Dawson (Table II-I).

Crop Yields

Crop yield variability across the four county area is doubtlessly the result of a combination of factors -- some of which may be effectively controlled or altered by management and others which cannot be affected in any manner. Nevertheless, the application of managerial skills to given sets of resources has played its part in the resulting land productivity, expressed here in crop yields per acre (Table II-J).

The first very obvious impression from the yield data presented in Table II-J is that irrigated acreages, on the average, yield considerably more than dryland acreages. In some instances, irrigated yields for given crops exceed twice the associated dryland yield. This result would ordinarily be expected, however, considering the varying qualities of irrigation throughout each of the four counties, the improved yields on irrigated acreages are actually quite impressive. Average irrigated hay yields of two to three tons per acre appear to be the rule in McCone, Dawson and Richland Counties. Corn silage on irrigated lands are averaging 16 to 28 tons per acre in those same three counties. In general, productivity per acre is highest in Dawson and Richland Counties and lowest in Garfield.

Crop Values

Data concerning value per acre harvested is the combined result of acreages harvested, crop yields, and prices per unit of saleable crop. In this sense, value per acre represents not only the application of managerial abilities to the crop production itself, but also to the marketing of

TABLE II-J
CROP YIELDS PER ACRE HARVESTED, 1967
GARFIELD, MCCONE, DAWSON & RICHLAND COUNTIES[1]

	Garfield		McCone		Dawson		Richland	
	I[2]	D[3]	I	D	I	D	I	D
Winter Wheat (bu)	28	26	--	27.5	36	30	34	30.5
Spring Wheat (bu)	--	16	--	19.5	44	20	44	23
Durum Wheat (bu)	--	10	--	24	--	22	47	20
Barley (bu)	35	31	--	30	53	32	48	33
Oats (bu)	--	25	--	33	65	33	63	33
Rye[4]	--	--	--	--	--	29	--	35
Flaxseed (bu)	--	4	--	11	--	6	--	8
All Hay (tons)	1.85	.86	2.50	.75	2.9	.78	2.64	.97
Corn Silage (tons)	--	4.5	16	5	28	4	18	5.5
Sugar Beets (tons)	--	--	--	--	18.3	--	16.8	--
Potatoes (tons)	--	--	--	--	130	35	150	50

[1] Source: *Montana Agricultural Statistics, 1968.*

[2] Irrigated acreage

[3] Dryland acreage

[4] Principally not irrigated

the final product. Value of crop harvested per acre is, then a reflection of the total managerial ability which is applied to a given resource base.

As would be expected, values per irrigated acre harvested far exceed those for dryland acres harvested. The average values for all crops presented in Table II-K indicate that the greatest response from irrigation and thus in farm receipts has occurred in Richland and Dawson Counties -- the primary result of fewer soils limitations and genuinely irrigated acreages, particularly in sugar beet and potato production. Response to irrigation in McCone, and particularly in Garfield, has been not quite as great as in Dawson or Richland which is undoubtedly the result of many factors, the largest of which is the fact that the irrigation quality has been extremely low as discussed above.

Livestock

As discussed in the beginning of this section, farmers and ranchers of the east central Montana study area depend heavily upon both crop and livestock production. Several of the crops which are grown are not, however, sold as cash crops, but are instead used on the same farm in support of livestock production. In this manner, much of the barley, corn silage and hay represented in Table II-I and Table II-J ultimately finds its way into livestock production where its contribution to farm receipts is finally realized only when the livestock is marketed.

Table II-L illustrates the importance of cattle and calves, swine, sheep and chickens to the area's livestock industry. In terms of numbers, cattle and sheep account for the largest portion of the livestock on farms and ranches. However, on a percentage basis, swine and chickens each account for nearly six percent of the number in the entire State. In all cases, except perhaps sheep, the general trends are toward increased numbers of livestock on area farms and ranches. Undoubtedly, the continuation of this trend will place greater demands on existing livestock support crops and may in fact require additional acres of productive land as well as increased yields on existing acreages. Application of top flight management abilities, including wise use of irrigation potential, could be the key to future growth of farming and ranching in the area.

TABLE II-K

VALUE PER ACRE HARVESTED, ALL CROPS --
IRRIGATED & DRYLAND ACREAGES, 1958-1967
GARFIELD, MCCONE, RICHLAND & DAWSON COUNTIES[1]

	Garfield		McCone		Richland		Dawson	
Year	I[2]	D[3]	I	D	I	D	I	D
1958	$[illegible]		$60.42		$84.17		$72.93	
1959	26.91		42.09		65.32		82.67	
1960	31.04		46.48		79.89		73.90	
1961	29.34		48.59		98.26		85.93	
1962	31.11		40.81		93.76		83.72	
1963	30.15		38.89		107.36		97.97	
1964	40.12		48.57		92.24		96.66	
1965	40.63		43.69		78.49		105.56	
1966	45.10		50.47		117.46		113.70	
1967	[illegible]		50.21		121.11		129.76	

[1]Source: *Montana Agricultural Statistics, 1968*
[2]Irrigated acreage
[3]Dryland acreage

TABLE II-L
LIVESTOCK ON FARMS & RANCHES
JANUARY 1, 1966, 1967 & 1968
GARFIELD, MCCONE, RICHLAND & DAWSON COUNTIES[1]

	Cattle & Calves			Swine		
County	1966	1967	1968	1966	1967	1968
Garfield	63,600	62,000	70,000	400	500	500
McCone	46,500	49,000	51,000	1,500	1,800	1,800
Richland	60,000	61,000	64,000	2,600	4,000	4,000
Dawson	49,400	51,000	56,000	2,000	2,500	2,300
Total	219,500	223,000	241,000	6,500	8,800	8,600
% of State	7.7%	7.7%	8.1%	5.3%	5.5%	5.3%

Garfield	132,500	131,000	132,000	5,700	5,300	5,000
McCone	33,500	34,000	32,000	13,800	13,600	15,000
Richland	18,000	22,000	19,000	21,000	27,000	24,000
Dawson	19,000	21,000	21,000	16,800	22,000	25,000
Total	203,000	208,000	204,000	57,300	67,900	[illegible]
% of State	15.9%	17.0%	17.5%	5.5%	5.8%	5.7%

[1] Source: *Montana Agricultural Statistics*, December, 1968

CHAPTER III

IDENTIFICATION OF POTENTIALLY IRRIGABLE LAND, LAND USE AND CURRENT LAND OWNERSHIP

IDENTIFICATION OF POTENTIALLY IRRIGABLE LAND, LAND USE AND CURRENT LAND OWNERSHIP

A. DELINEATION OF THE STUDY AREA

The study area, for which all materials have been assembled in this preliminary feasibility survey, includes all of Garfield and McCone Counties and the western portions of Dawson and Richland Counties.

The study area is bounded on the north from R30E to R55E along the Missouri River. The Missouri River and Fort Peck Reservoir also serve as the northern boundaries for Garfield, McCone and Richland Counties. The northern boundary of the study area is exactly the boundaries of these three counties, with only a portion of Richland County included. This northern boundary is indeed very logical, because it serves as the terminus for all of the major drainage in the entire study area.

The study area is bounded on the west by the Musselshell River, which also serves as the western boundary of Garfield County. Approximately one-fourth of the land area of Garfield County drains toward the Musselshell River rather than toward the northern boundary of the Missouri River.

The eastern boundary of the study area runs along the top of the ridge in Dawson and Richland Counties, which divides the drainage in these two counties between the Missouri and Yellowstone Rivers. The western parts of Dawson and Richland drain into the Missouri River via the Redwater River, which is one of the primary drainages in the study area. The legal description of the boundary in Dawson County begins in T17N, R51E and generally follows the ridge line toward a point in Richland County in T28N, R51E. There are 17 townships included in the study area from Dawson County and 22 townships in Richland County. Detailed description or identification of the exact boundaries can be found in Figure III-1, which follows in Part C of the current chapter.

The southern boundary of the study area consists of the southern boundaries of Garfield and McCone Counties. Practically all of McCone and Garfield Counties drain to the north through the major drainages of the Big Dry and Little Dry Creeks in Garfield County and the Redwater River in McCone County. There are only very minor portions of either of these counties that do not drain toward the north or northeast, into the Missouri, via these major tributaries.

The western portion of Garfield County does drain to the west and north into the Musselshell River, as mentioned earlier.

In summary, the study area boundaries are: (1) the Missouri River and Fort Peck Reservoir on the north, (2)the Musselshell River on the west, (3) the Garfield and McCone County boundaries on the south and (4) the western portions of Dawson and Richland Counties, outside of the Yellowstone drainage, which drain into the Redwater River. Designation of these study area boundaries, at this point, does not imply that they are to be the recommended conservancy district boundaries. The boundaries serve only to delineate the study area, as studied in detail in this preliminary feasibility report.

B. METHODOLOGY FOR IDENTIFICATION OF LAND CHARACTERISTICS -- SOILS -- LAND USE -- LAND OWNERSHIP

Soils

A preliminary reconnaissance survey of the study area was conducted by the research staff to determine quantity, location and class of potentially irrigable land in the proposed conservancy district. It should be emphasized that this is a report of a reconnaissance survey and that the ultimate feasibility of actual irrigation development must be based on a detailed soils study, as well as other relevant factors. As these results are from a reconnaissance survey, there is little doubt that some potentially irrigable areas were omitted and some non-irrigable areas were included. The general approach in this reconnaissance survey, however, can be described as "conservative". Without a detailed survey, the exact quantity and type of irrigable land cannot be designated. The history of developed irrigation projects, world-wide, dictates a conservative approach at this stage. Within this conservative framework the estimate of potentially irrigable lands is subject to an error of up to plus or minus 15 percent, and it is much more likely to be low rather than high.

The classification of lands as non-irrigable or irrigable, and the classification within the irrigable areas were based on criteria as reported by Mr. Glenn Smith, Chief of Land Classification, Montana Water Resources Board.[1]

[1] *Land Classification Standards & Procedures; Missouri Basin, Montana*, Glenn R. Smith, Chief of Land Classification, Montana Resources Board, Helena, Montana. October 21, 1968.

As pointed out by Smith and Cawlfield[2], potentially irrigable land must have soil, topography and drainage features which will withstand a sustained irrigated agriculture. On the basis of these factors, the land was classified as Class I, II or III and as irrigable or non-irrigable. Class I lands have a potentially high productivity level under irrigation, Class II an intermediate productivity level and Class III lands have the lowest acceptable productivity level under irrigation. A deficiency in any soil, topographical or drainage feature may lower the class of a land area by one or more classes.

Use of this classification system does not provide for consideration of other factors which may ultimately prevent irrigation of a given land area. For example, lands which occur on high, broad ridges between drainage systems may meet the soil, topographical and drainage criteria for irrigability, but it may be completely impractical to lift water to these areas. This is particularly important if the land area is limited in extent and rather isolated, or if it is Class III land. Areas listed in this report as potentially irrigable include such lands that may eventually be eliminated by engineering, economic or other limitations.

The actual land classification was conducted through a combination of on-site investigations (at times accompanied by Soil Conservation Service personnel from the areas), intensive use of S.C.S. classification maps for those areas that have been surveyed, published reconnaissance soil surveys of Richland and McCone Counties[3], extensive use of maps prepared by Mr. Dave R. Cawlfield, Consulting Soil Scientist, Montana Water Resources Board and consultation with S.C.S. personnel in the field. These included Mr. Douglas Campbell of Garfield County, Mr. Joe Icenhower of McCone County, Mr. Pedro Pescador of Richland County and Mr. Donald Anderson of Dawson County. Much of the recent soil survey in the area of the Redwater Creek drainage, which passes through Dawson County, had been completed by Mr. Pescador. Therefore, he was able to provide a first-hand briefing on soils encountered, their

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[2] In *Water Resources Survey, Glacier County,* Montana Water Resources Board, Helena, Montana, September, 1969, p. 15.

[3] *Soils of McCone County,* Soil Reconnaissance of Montana, Preliminary Report; Montana State College, Bulletin 514, October, 1955. *Soils of Richland County,* Soil Reconnaissance of Montana, Preliminary Report, Montana State College, Bulletin 515, November, 1955.

characteristics and related information. He also accompanied the soils team on a tour of the entire drainage areas of the Redwater, Prairie Elk, McGuire and Nelson Creeks and their major tributaries. In addition other S.C.S. personnel were consulted, and information concerning the agricultural situation was obtained from County Cooperative Extension agents, especially Mr. Robert G. Brastrup, McCone County.

Land Use

Contact prints or aerial photos were available for the entire study area, through the western office of the Agricultural Stabilization and Conservation Service in Denver, Colorado. These aerial photos were obtained from the A.S.C.S. and assembled for the entire study area for use by the research staff. Larger scale aerial photos were obtained and used for all areas within the study area where potentially irrigable lands were located. These aerial photos were also used to assist directly in the identification of present land use within the study area.

Present land use maps were prepared, for each township in the study area, on a scale of two inches to the mile. This was accomplished in very close cooperation with the A.S.C.S. and S.C.S. offices in the respective counties. Many of the acreages, as to present cropland, were also obtained directly from the A.S.C.S. Total cropland acreages were determined directly from these materials and data sources and were initially defined as: (1) land under crop production, (2) land in summer fallow, (3) diverted cropland, which is idle or in various agricultural programs, (4) cultivated land for hay production and (5) small acreages of presently irrigated land. These detailed land use maps, as prepared for use in this study, are on file and available in the offices of T.A.P., Incorporated, Bozeman, Montana.

Land Ownership

Present land ownership maps were also prepared for all sections of the study area. Lands, in terms of ownership, were classified into several categories as follows: (1) federal ownership in wildlife refuges, (2) federal ownership other than wildlife refuges, (3) land in state ownership and (4) fee title land of the Burlington-Northern Railway Company and (5) all other private ownership.

All of the information on state and federal ownership

was obtained from the Bureau of Land Management unit maps which were constructed on a scale of one-half inch to the mile. These maps were current as of the preparation date of 1964. For the purpose of this study it was assumed that the federal and state ownership had not changed appreciably since 1964, however, in certain areas this assumption would require further examination in continued detailed investigations.

The Burlington-Northern Railway Company provided excellent cooperation in relationship to this study and also supplied a map of the study area, which accurately delineated the ownership of the railroad lands. Each of the detailed maps, showing land use in this study, which will be referred to in Part C of the current chapter, show the land for which the Burlington-Northern Railroad has fee title. This data was current as of 1955, and it is anticipated that only minor change has occurred in this ownership since that time. The maps supplied to the research staff also contained other land classifications held by the Burlington-Northern Railroad for which all or part of the mineral rights had been retained by the Burlington-Northern, with the actual land being transferred to other private ownership. The study area does, in fact, contain very large acreages of property for which the mineral rights are retained by the Burlington-Northern Railroad, but for which the land has been sold. This has not been identified on the land use maps, but would certainly be important to the potential industrial development of the area's minerals and coal, as is discussed in detail in Chapter IV.

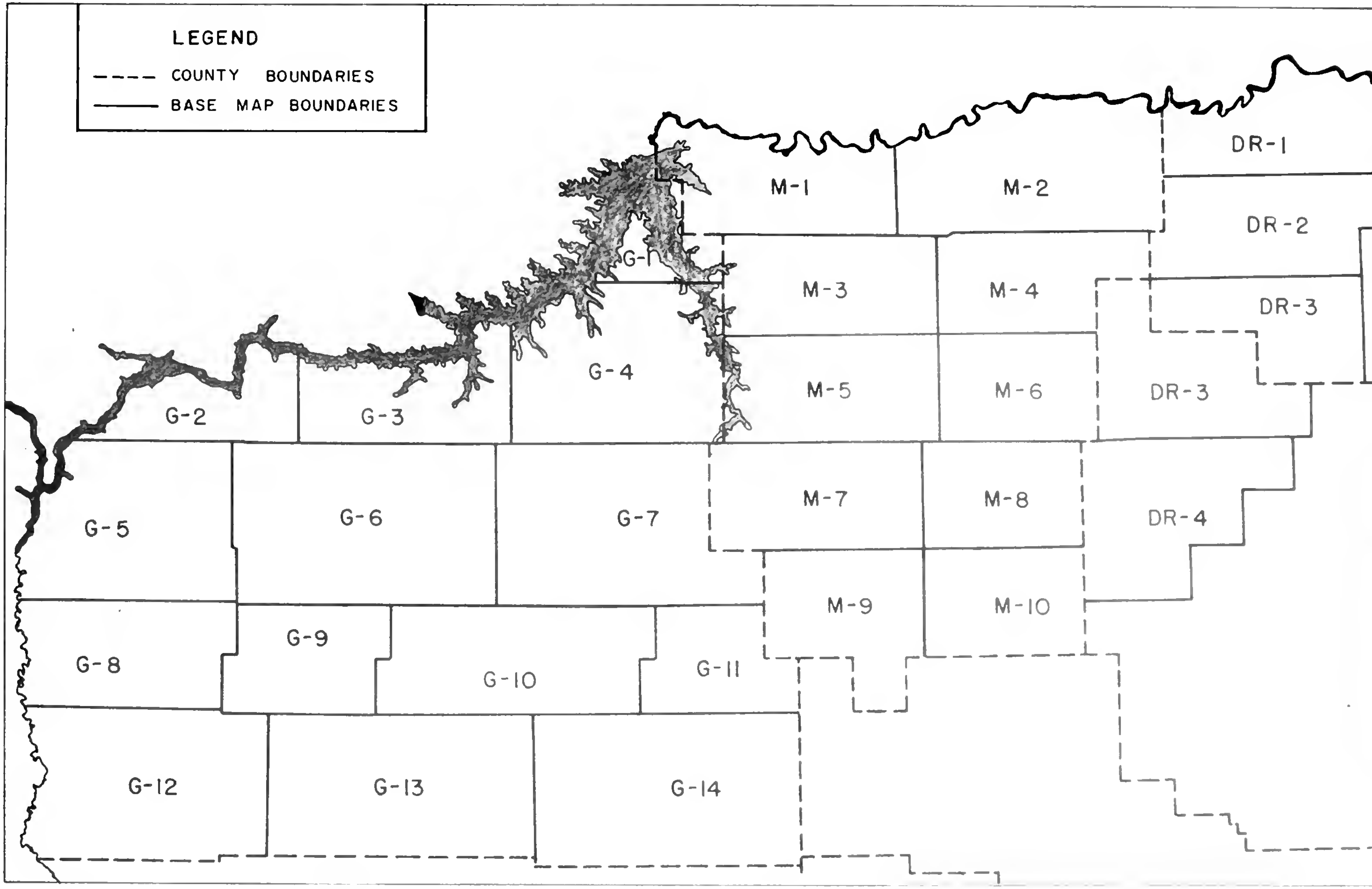
C. SYSTEM OF PRESENTATION

Sub-Area Orientation

Figure III-1 is a key map of the study sub-areas, which were selected for presentation purposes only. This key map illustrates the location of each of the 28 total sub-areas within the study area. Of the total 28 sub-areas, 14 are in Garfield County (G-1, G-2,...G-14), 10 are in McCone County (M-1, M-2,...M-10) and 4 are in Dawson-Richland Counties (DR-1, DR-2, DR-3, DR-4).

Detailed Sub-Area Maps and Enumerative Data

In general, each of the 28 sub-areas is described by a set of six corresponding maps (plates), which are



KEY MAP OF SUB-AREA LOCATIONS

Figure III - 1

Scale: 1:1,000,000
1 inch equals approx. 16 mi

numbered 1, 2, 3, 4, 5 and 6A, respectively. These maps may be referred to in the detailed map assembly, which accompanies this report. Each of these plates, within a given set, provides specific types of information relative to characteristics of the study area. As an example, a typical complete set of maps for McCone Sub-area 5 (M-5) would include the following plates:

Sub-Area	Plate No.	Plate Title
McCone 5:	1	POTENTIALLY IRRIGABLE LAND - LAND USE
McCone 5:	2	POTENTIALLY IRRIGABLE LAND - LAND OWNERSHIP
McCone 5:	3	ALTERNATE IRRIGATION SYSTEMS - POTENTIALLY IRRIGABLE LAND
McCone 5:	4	ALTERNATE IRRIGATION SYSTEMS - LAND OWNERSHIP
McCone 5:	5	ALTERNATE IRRIGATION SYSTEMS - LAND USE
McCone 5:	6A	PRESENT IRRIGATED LAND

More specifically, each sub-area plate designation consists of:

1. The county name (Garfield, McCone or Dawson-Richland)
2. The sub-area within that county (1, 2,...14)
3. The specific map (plate) number within the set of six maps (1, 2, 3, 4, 5 or 6A).

In terms of reference to the text presentation, the maps (plates) within the detailed map assembly as referred to above, appear as follows:

Text	Detailed Map Assembly	Plates
Chapter III	Section I	1,2
Chapter V	Section II	3,4,5
--	Section III	6A

As clearly indicated above, Plates 1 and 2 for each of the 28 sub-areas appear in Section I of the detailed map assembly and illustrate the relationship of the potentially irrigable lands to: (1) current land use (cropland or rangeland) and (2) current land ownership (state, federal, wildlife refuge, Burlington-Northern and other private). It should be noted that Plates 3, 4 and 5, which appear in Section II of the map assembly, exist only when segments of the proposed irrigation system are contained within a given sub-area. Plate 6A exists for each of the 28 sub-areas. Refer to Table III-A for an inventory of the maps contained in the detailed map assembly.

TABLE III-A
INVENTORY OF DESCRIPTIVE PLATES PRESENT
IN THE DETAILED MAP ASSEMBLY

	TITLE OF PLATE					
	Potentially Irrigable Land		Alternate Irrigation Systems			Present Irrigated Land
	Land Use	Land Ownership	Potentially Irrigable Land	Land Use	Land Ownership	
Corresponding Plate No:	1	2	3	4	5	6A
Sub-Area						
Garfield						
G-1:	x[1]	x	NP[2]	NP	NP	x
G-2:	x	x	NP	x	x	x
G-3:	x	x	x	x	x	x
G-4:	x	x	x	x	x	x
G-5:	x	x	NP	NP	NP	x
G-6:	x	x	x	x	x	x
G-7:	x	x	x	x	x	x
G-8:	x	x	NP	NP	NP	x
G-9:	x	x	NP	NP	NP	x
G-10:	x	x	NP	NP	NP	x
G-11:	x	x	NP	NP	NP	x
G-12:	x	x	NP	NP	NP	x
G-13:	x	x	NP	NP	NP	x
G-14:	x	x	NP	NP	NP	x
McCone						
M-1:	x	x	x	x	x	x
M-2:	x	x	x	x	x	x
M-3:	x	x	x	x	x	x
M-4:	x	x	x	x	x	x
M-5:	x	x	x	x	x	x
M-6:	x	x	x	x	x	x
M-7:	x	x	x	x	x	x
M-8:	x	x	x	x	x	x
M-9:	x	x	NP	NP	NP	x
M-10:	x	x	NP	NP	NP	x
Dawson - Richland						
DR-1:	x	x	NP	NP	NP	x
DR-2:	x	x	x	x	x	x
DR-3:	x	x	x	x	x	x
DR-4:	x	x	x	x	x	x

[1] Presence of a given plate in the accompanying detailed map assembly is indicated by an "x".

[2] Indicates that the particular plate in question does not appear in the accompanying detailed map assembly. This plate has been omitted from the series, because one of its descriptive characteristics does not exist for that sub-area.

A color-coded enumerative data page which corresponds to each Plate 1, is provided at the end of Chapter III, to more precisely enumerate the potentially irrigable acres and land use information contained in Plate 1 for each of the 28 sub-areas. Cropland and rangeland replacement by township is provided, both in terms of numerical acreages and visually, as is the breakdown by land class. With reference to land classification, only the Class II and Class III categories are indicated, because of the rather insignificant acreages of Class I land within the study area. It should be noted, then, that Class II land, as designated in the enumerative data, includes extremely small acreages of Class I land.

In terms of detail, the map (plate) and color-coded enumerative data section of this particular chapter, provide answers, on a township basis, to two vital questions:

1. What types of current land use would be replaced by the potentially irrigable acres?

2. What type of land ownership is involved in the potentially irrigable acres?

Present Irrigated Land

The acreage of present irrigated land within the entire study area is quite small (see Section III of the Detailed Map Assembly). It is also obvious that much of the land, which is classified as present irrigated land, is not presently irrigated in the same sense that water development for new irrigation is being studied in this report. The majority of the acreage in the study area that is classified as present irrigated land, is land that receives varied degrees of flood irrigation, once, or at most twice a year, in times of peak runoff in the various drainages. There are, however, some highly productive and well-developed irrigated lands along the Missouri River, which forms the northern boundary of the study area, but most of the other land does not fit this category.

The information and data presented on present irrigated land was assembled in joint cooperation between the research team conducting this study and the Montana Water Resources Board. The present irrigated land, which was identified in McCone, Dawson and Richland Counties, was supplied directly to the research staff by the Montana Water Resources Board. The present irrigated land identified in Garfield County was assembled by using data from the Montana Water Resources Board, as well as primary data which was collected by the research staff.

Detailed maps showing the present irrigated land are found in Section III of the Detailed Map Assembly of the 28 sub-areas described previously in Part C of this chapter. All of the plates showing present irrigated land are labeled 6A, with the present irrigated land areas shown in green. It is easily observed from these maps, that the present irrigated land acreage is not only extremely small, but also extremely scattered throughout the study area. It is also fair to say, that most of the acreage which is classified or shown as present irrigated land is irrigated much less intensively than that which is commonly regarded as irrigated land.

D. DELINEATION OF POTENTIALLY IRRIGABLE LAND AND DATA SIGNIFICANCE

Geographic and Physiographic Characteristics

The proposed conservancy district is located in the dissected residual plains of east central Montana. The dominant substrata of the area is the Fort Union Formation consisting of clay shale, siltstone and sandstone, with local lenses of limestone and numerous lignite beds. The northern portion of the area is underlain, in places, by the Hell Creek Formation, consisting of sandstone, shale clay and mudstone and by the Fox Hills Sandstone. The northern part of the area was covered by continental glaciation, but glacial till is not extensive in the area. Only the northeastern corner of McCone County and northwestern part of Richland County are covered with glacial till. Alluvium, consisting of silt, sand and gravel and including some terrace deposits and glacial drift material has been deposited to various thicknesses along most of the major stream channels of the area.

The area can be generally categorized as rough and broken, sharply rolling, gently rolling or relatively level valley floors. The potentially irrigable areas are found in the latter two categories, which comprise a relatively small percentage of the entire land area involved.

The area drains generally in an easterly, northeasterly or northerly direction. The major drainage basin in the western part of the proposed conservancy district consists of the Big Dry and Little Dry Creeks and their tributaries (Sand Creek, Lone Tree Creek, Smoky Butte Creek, Vail Creek and other smaller creeks). The general direction of drainage is easterly for the major portion of this basin. The Little Dry Creek and the Big Dry Creek, from their

confluence to where they drain into Fort Peck Reservoir, drain in a northeasterly direction. The eastern portion of the proposed conservancy district is separated from the western by a north-south divide of several hundred feet elevation. Three small streams drain in a north-westerly direction down the western slope of this divide. These streams, McGuire, Nelson and Timber Creeks, are associated with some minor areas of potentially irrigable lands.

The major drainage on the east side of the north-south divide is the Redwater Creek. Numerous contributing creeks provide the major portion of potentially irrigable lands along their drainages. These include Lisk, Duck, Ash, Tusler, Trail, Dirty, Cotter, Stony Butte, Antelope, Horse, Lost, Cow and Wolf Creeks. In addition, the East Redwater Creek provides the major drainage out of Richland County into the Redwater Creek.

In the northern portion of this eastern section of the proposed conservancy district, the Prairie Elk Creek provides a major drainage. It flows almost directly northward into the Missouri River. It and its major contributing creeks (the Figure 8, Flying V, Shade and Remutha) have several areas of potentially irrigable lands along their drainages, particularly in the upper reaches of the drainage. Rough, broken lands and excessive salts occur along the lower half of this drainage.

Parent Materials, Salts and Topographic Characteristics

The soils of the area developed from existing geological material. Thus, they are basically from three sources; the residual materials, largely Fort Union and associated formations, the glacial till and the alluvium deposits. Soils of the benches and slopes of the tributaries of the Redwater and, to a lesser extent, the Big and Little Dry Creeks developed from residual materials. Soils of the benches and rolling land in the northern part of McCone and Richland Counties developed from glacial till. Soils of the flood plains along the Big and Little Dry Creeks, the Musselshell, the Missouri, the Redwater and Prairie Elk Creek are fairly recent alluvium. Older alluvium, from glacial lakes, is the parent material for the soils of some of the land above the flood plains of the Big and Little Dry Creeks, the upper regions of the Redwater and Prairie Elk Creek. Since these three parent materials varied appreciably in their original composition, the soils are likewise variable over the area. For instance, soils

derived from Fort Union materials might range from sandy loam to clay depending upon the part of the formation making up the parent material. Even greater differences in soils properties can be expected in soils developed in alluvium. For instance, soils of the flood plains along the Missouri often vary from sandy material to Bowdoin clay in only a short distance.

In general, all of the parent materials contained appreciable quantities of cations (salts), especially sodium, calcium and magnesium. The salts are present in various combinations, with a wide range of solubilities. Since the soils formed under conditions of low rainfall, the salts have not been completely removed from the soil profile. In some areas of the proposed conservancy district, the concentration of salts in the profile is high enough for the soil to be classified as "saline", indicating that the growth of many plants is inhibited.

Irrigation of saline soils poses serious problems and may end in disaster unless the soil is very permeable and deep and/or extreme care is used in development drainage of the project and in subsequent irrigation practices. In fact, slightly or non-saline soils containing salts can be, and often are, essentially destroyed by irrigation, because the additional water concentrates the salts and deposits them in an adjacent agricultural area. Unfortunately, soils of the areas within the proposed district, which contain salts, are not especially permeable. Removal of salts by irrigation leaching would be slow and expensive. Moreover, many soils within the proposed district are underlain by slowly permeable clays or nearly impermeable bedrock. This condition is especially dangerous where salts are present. Water will move downward, through the soil profile, pick up a load of soluble salts and then, upon reaching the slowly permeable layer, it will move downslope until it emerges at the surface. Here it will evaporate, creating a saline seep spot. These seep spots tend to enlarge in area each year and may eventually ruin large expanses of land. Within the proposed district, the possibility of this occurring is greatest in the soils developed from residual bedrock materials. Lands along tributaries of the Big and Little Dry Creeks in Garfield County and those in the lower half of Prairie Elk Drainage in McCone County are probably the most susceptible to this possibility.

Compilation of salinity test results of soil test data for the three most recent fiscal years, 1967 to 1970, provides some indication of the extent of the potential

salt problem.[6] Table III-B presents a summary of salt status of these soil samples, by drainage. Unfortunately, the number of samples is too small to be reliable, particularly for those drainages within Garfield County. Furthermore, these samples represent primarily areas which are currently being farmed. Areas which may not be farmed for reasons of salinity generally have not been tested. The percentages of potentially salt affected lands may be somewhat higher than suggested by these data. Again, the necessity for detailed studies of the area to determine these facts must be emphasized.

TABLE III-B

Number and Percent of Soil Samples Tested at Various Salinity Hazards within Specific Drainages of the Proposed Conservancy District, 1967-1970 Soil Test Results

		Salt Hazard		
Drainage*	Soil Samples	None	Slight to Moderate	Extreme
Big Dry Creek	No.	7	0	0
	%	100	--	--
Little Dry Creek	No.	10	2	0
	%	83	17	--
Musselshell River	No.	3	5	2
	%	30	50	20
Upper Redwater Creek	No.	45	4	1
	%	90	8	2
Lower Redwater Creek	No.	23	2	1
	%	88	8	4
Prairie Elk Creek	No.	19	3	1
	%	83	13	4

*Including tributary stream areas. Upper and Lower Redwater division made approximately where stream flows from McCone into Dawson County.

Montana State University Soil Testing Laboratory, Bozeman, Montana.

In addition to salt concentration, a dominance of sodium, even in non-saline areas, is extremely detrimental to irrigation development. Sodium reacts with clay causing a soil to be essentially impermeable. Much of the area is sodium affected and a considerable amount is sodium dominated. Delineation of these soils, their exact locations and their extent must be determined through detailed soils studies, prior to final development of irrigation in the proposed district.

A brief look at the area, either on-site or with aerial photos, leaves little doubt that topography is the major factor resulting in lands being classified as non-irrigable. Most of the area is far too rough to irrigate by any technique. Furthermore, much of the land classified as irrigable is Class III, because of topography, limiting irrigation on these areas to sprinkler systems or wild flooding. However, the major factor limiting irrigability of soils, within topographically favorable areas, is the salt-sodium status and limited profile permeability. Most of the land qualifying as Class I, from the standpoint of topography, lies along the Redwater Creek drainage around Weldon or adjacent to the Missouri River.

Fertility Considerations

A survey of the fertility status of soils, within the proposed conservancy district, was made. This was accomplished by on-site observation of types of vegetation, deficiency symptom appearance of crops, general yield levels obtained over the long term and compilation of soil test results from the Montana State University Soils Testing Laboratory.

General appearance of crops in the area leaves little doubt that nitrogen is a major limiting nutrient for crop production. Soil test results verify this observation. Nearly all soil samples tested from this area are low in organic matter (an indirect indication of the nitrogen supplying power of soils). In addition phosphorus is very deficient in soils of the area. Nearly 75 percent of samples tested were found to be "very low" in their level of phosphorus while only 8 percent of them tested "high" or would be considered to have adequate phosphorus for crop production. The potassium content of these soils appears to be quite adequate, with all soils testing medium to high.

It is apparent that great care should be exercised in

delineating the soils to be irrigated within the area. Detailed drainage investigations should be conducted, along with the detailed soil survey. Adequate surface and sub-surface drainage facilities should be included, from the beginning, as a development cost for detailed studies of irrigation on-farm in this area. Also, on those acreages which are favorable for irrigation, it will be necessary to supply adequate amounts of nutrients through application of fertilizers--particularly nitrogen and phosphorus--if sustained high yields are to be expected.

Soils Descriptions

Soil Conservation Service detailed descriptions of the major soils, which are potentially irrigable, within the proposed conservancy district are included in Appendix B of this report. The names given to the soil series are subject to change and are included for identification purposes only. However, a good idea of the profile characteristics of soils in the area can be obtained from a review of these descriptions. Most of the area has not been detail soil surveyed, but our preliminary studies indicated that the soils described here are likely to compose the large majority of irrigable acres. Prior to a detailed soils study, it is not possible to estimate the relative amounts of these soils in the area or to designate the location of the specific soils. The general location, in terms of the type of parent material in which these soils formed, is given below:

TYPE OF PARENT MATERIAL

Residual	Alluvial	Glacial
Bainville	Bowdoin	Marias
Charma	Cherry	Vida
McRae	Havre	
Midway	Lohmiller	
Tullock	Nihill	
	Straw	
	Wolf Point	

The Potentially Irrigable Land Identified

Land areas were classified as potentially irrigable and identified on two inch to the mile scale maps for each of the townships in the study area. These outlines of the potentially irrigable lands were each planimetered, by land class and individual area, to determine the acreage of potentially irrigable land for each township in the study area.

It was impossible to include these two inch to the mile scale maps in the report, in any meaningful way, and thus this data has been mapped for the report on a scale of one-half inch to the mile. The original detailed maps, identifying potentially irrigable lands as they were delineated, are on file, however, in the office of T.A.P., Incorporated, Bozeman, Montana.

The maps in Section I of the detailed map assembly show the areas of potentially irrigable land, as they have been delineated in this study. The detail is found on Plates 1 and 2 for each one of the 28 sub-areas of the study area.

Each of the 28 designated sub-areas has a corresponding map entitled "POTENTIALLY IRRIGABLE LAND - PRESENT LAND USE", which indicates the concentrations of cropland and rangeland in the individual townships and sections of those townships. Cropland is shown on the maps by concentrations of gold dots. In addition, on each Plate 1, there are areas which are designated in yellow--these indicate the potentially irrigable land, as identified and planimetered from maps of two inch to the mile scale. Again, all of the land area inside these yellow areas is not necessarily potentially irrigable. These delineated areas are intended only to indicate the general location of the acreages of potentially irrigable land. Although a significant amount of the land which is included in any given yellow area may not be potentially irrigable, the delineation will always encompass acreages of potentially irrigable land.

Each of the 28 sub-areas also has a corresponding Plate 2, which is entitled "POTENTIALLY IRRIGABLE LAND - PRESENT LAND OWNERSHIP". The ownership was divided into two classifications of federal ownership, state ownership, Burlington-Northern Railroad ownership and private ownership other than Burlington-Northern Railroad.

It is believed that these detailed maps will be extremely helpful in further study as concerns: (1) the establishment of a conservancy district and (2) the implementation of plans to develop irrigated lands within the study area.

As indicated previously, Plate 1 shows the general location of the potentially irrigable lands in relationship to present cropland and rangeland within the study area. In addition to this Plate 1 for each of the 28 sub-areas, there is a corresponding table of enumerative data which is

provided at the end of the current chapter, to assist in interpretation.

An example would be that McCone County Plate 6:1 contains detail on six townships. These are T21N and T22N and R47E, R48E and R49E. Plate 6:1 shows, visually, that potentially irrigable land has been identified in each of the six townships. There are, however, significant differences in terms of the amount of potentially irrigable in each of the townships and also significant differences in terms of the present land use within the townships. The "Corresponding Enumerative Data for McCone County Plate 6:1" identifies, in a precise fashion, the total cropland as well as the present use of that land, which has been delineated as potentially irrigable. These tables are designed in three colors for ease of reading. For each township and range there is a classification of Class II and Class III land, as well as total potentially irrigable land. In addition, the table shows, in red, the number of acres of the potentially irrigable land that is presently in cropland, and, in green, the number of acres that is presently in rangeland.

A specific example is T22N, R47E. (McCone Sub-area 6), which contains 15,682 acres of cropland at the present time. In addition to that, there has been identified or delineated 974 total potentially irrigable acres within that township, with 576 acres classified as Class III and 398 classified as Class II. The enumerative data shows that of the Class III land, 437 acres are presently in crops and 139 acres are presently being used for range. In total, out of the 974 potentially irrigable acres, 795 are now in cropland with 179 in rangeland. It cannot be over-emphasized, that this is extremely useful and beneficial data in terms of assessing the significance of the irrigation of any one of these potentially irrigable areas.

Plate 6:2 for each of the 28 sub-areas shows the present land ownership in relationship to the potentially irrigable land areas. This information is vital in terms of: (1) implementation of the study results and (2) carrying the work of this study into either detailed study or other implementation phases. Plate 2 clearly indicates the ownership of the land which has been delineated as potentially irrigable. It is believed that these plates, contained in the detailed map assembly, clearly show the data and speak for themselves in terms of interpretation. Therefore, detailed enumerative material has not been supplied in relationship to these maps, as was the case

with potentially irrigable land and present land use.

This section of the report, including both enumerative data and maps, provides a tremendous data base from which to launch further planning of the area's development of water resources. The following enumerative data is presented, in detailed form specifically for the above purpose.

GARFIELD COUNTY ENUMERATIVE DATA ON
POTENTIALLY IRRIGATED LAND - PRESENT LAND USE
FOR ALL 14 SUB-AREAS OF GARFIELD COUNTY

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 1:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use:	Cropland - red Rangeland - green	
Total Cropland	Legal Description	Class II	Class III	Total
--	T. 26N - R. 41E	--	--	--
--	T. 25N - R. 40E	--	--	--
--	T. 25N - R. 41E	--	--	--
--	T. 24N - R. 40E	--	--	--
293	T. 24N - R. 41E	--	--	--
--	T. 24N - R. 42E	--	--	--

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 2:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Class II	Class III	Cropland - red Rangeland - green Total
--	T. 22N - R. 32E	--	--	--
--	T. 22N - R. 33E	--	--	--
--	T. 22N - R. 34E	--	--	--
--	T. 21N - R. 30E	--	--	--
--	T. 21N - R. 31E	--	--	--
145	T. 21N - R. 32E	--	--	--
970	T. 21N - R. 33E	--	--	--
1,729	T. 21N - R. 34E	--	--	--

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 3:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use: Cropland - red; Rangeland - green		
Total Cropland	Legal Description	Class II	Class III	Total
--	T. 23N - R. 38E	--	--	--
--	T. 22N - R. 35E	--	--	--
--	T. 22N - R. 36E	--	--	--
--	T. 22N - R. 37E	--	--	--
--	T. 22N - R. 38E	--	--	--
1,114	T. 21N - R. 35E	--	--	--
369	T. 21N - R. 36E	--	--	--
104	T. 21N - R. 37E	--	--	--
--	T. 21N - R. 38E	--	--	--

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 4:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Present Use: Class II	Cropland - red Rangeland - green Class III	Total
--	T. 23N - R. 39E	--	--	--
--	T. 23N - R. 40E	--	--	--
313	T. 23N - R. 41E	--	--	--
344	T. 23N - R. 42E	--	--	--
49	T. 22N - R. 39E	-- -- --	14 12 2	14 12 2
78	T. 22N - R. 40E	--	--	--
439	T. 22N - R. 41E	--	--	--
10	T. 22N - R. 42E	--	--	--
1,121	T. 21N - R. 39E	667 2 665	143 80 63	810 82 728
1,381	T. 21N - R. 40E	608 236 372	238 -- 238	846 236 610
440	T. 21N - R. 41E	--	--	--
45	T. 21N - R. 42E	--	--	--

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 5:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use:	Cropland - red Rangeland - green	
Total Cropland	Legal Description	Class II	Class III	Total
--	T. 20N - R. 30E	--	--	--
286	T. 20N - R. 31E[1]	--	--	--
761	T. 20N - R. 32E	--	--	--
4,733	T. 20N - R. 33E	--	--	--
--	T. 19N - R. 30E	-- -- --	998 -- 998	998 -- 998
--	T. 19N - R. 31E	--	--	--
212	T. 19N - R. 32E	--	--	--
2,195	T. 19N - R. 33E	--	--	--
211	T. 18N - R. 29E[2] & R. 30E	214 -- 214	1,415 40 1,375	1,629 40 1,589
31	T. 18N - R. 31E	--	--	--
932	T. 18N - R. 32E	--	--	--
1,165	T. 18N - R. 33E	--	--	--

[1] 3.1 inches per mile aerial photographs were unavailable at the time of tabulation for Sections 28-33. The acreage is less than 150 acres, estimated from half inch per mile aerial photo. The estimated acreage is not included since the error will be out of reason.

[2] Acreage includes Sections 1, 12, 13, 24, 25 and 36 from T. 18N - R. 29E and all of T. 18N - R. 30E.

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)	Present Use: Cropland - [illegible] Rangeland - green	
Total Cropland	Legal Description	Class II	Class III	Total
4,186	T. 20N - R. 34E	-- -- --	80 -- 80	80 -- 80
5,982	T. 20N - R. 35E	363 [illegible] 70	23 [illegible] 21	386 [illegible] 91
4,994	T. 20N - R. 36E	175 152 23	206 76 130	381 228 153
1,734	T. 20N - R. 37E	--	--	--
957	T. 20N - R. 38E	-- -- --	226 22 204	226 22 204
6,958	T. 19N - R. 34E	253 96 157	981 297 684	1,234 [illegible] 841
3,514	T. 19N - R. 35E	915 [illegible] 417	1,149 [illegible] 534	2,064 [illegible] 951
5,269	T. 19N - R. 36E	613 485 128	1,290 245 1,045	1,903 730 1,173
3,494	T. 19N - R. 37E	147 92 55	800 392 408	947 484 463
1,122	T. 19N - R. 38E	37 11 26	464 [illegible] 320	501 155 346
1,697	T. 18N - R. 34E	262 44 218	919 80 839	1,181 [illegible] 1,057
2,495	T. 18N - R. 35E	222 [illegible] 82	810 [illegible] 573	1,032 [illegible] 655
1,049	T. 18N - R. 36E	40 -- 40	901 [illegible] 745	941 [illegible] 785
1,133	T. 18N - R. 37E	837 53 784	-- -- --	837 53 784
890	T. 18N - R. 38E	11 -- 11	717 57 660	728 57 671

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Present Use: Class II	Cropland - Rangeland - green Class III	Total
875	T. 20N - R. 39E	874 [illegible] 658	-- -- --	874 [illegible] 658
59	T. 20N - R. 40E	616 25 591	43 -- 43	659 [illegible] 634
295	T. 20N - R. 41E	1,086 [illegible] 891	712 [illegible] 652	1,798 255 1,543
223	T. 20N - R. 42E	-- -- --	707 [illegible] 687	707 [illegible] 687
912	T. 19N - R. 39E	491 204 287	498 [illegible] 439	989 263 726
378	T. 19N - R. 40E	277 5 272	200 57 143	477 62 415
45	T. 19N - R. 41E	--	--	--
1,324	T. 19N - R. 42E	-- -- --	2,477 739 1,738	2,477 739 1,738
490	T. 18N - R. 39E	-- -- --	1,710 213 1,497	1,710 213 1,497
863	T. 18N - R. 40E	555 247 308	378 [illegible] 282	933 [illegible] 590
104	T. 18N - R. 41E	144 23 121	466 [illegible] 424	610 [illegible] 545
307	T. 18N - R. 42E	-- -- --	942 51 891	942 51 891
2,792	T. 18N - R. 43E	395 4 391	-- -- --	395 [illegible] 391

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 8:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Present Use: Class II	Cropland -red Rangeland -green Class III	Total
290	T. 17N - R. 29E[1] & R. 30E	-- -- --	867 188 679	867 188 679
505	T. 17N - R. 31E	--	--	--
558	T. 17N - R. 32E	--	--	--
941	T. 17N - R. 33E	--	--	--
190	T. 16N - R. 30E	221 120 101	483 10 473	704 130 574
130	T. 16N - R. 31E	--	--	--
535	T. 16N - R. 32E	--	--	--
866	T. 16N - R. 33E	--	--	--

[1] Acreage includes Sections 1, 12, 13 and 36 from T. 17N - R. 29E and all acreage in T. 17N - R. 30E.

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 9:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use: Cropland - red; Rangeland - green		
Total Cropland	Legal Description	Class II	Class III	Total
1,458	T. 17N - R. 34E	181 50 131	1,004 333 671	1,185 383 802
689	T. 17N - R. 35E	299 11 288	64 35 29	363 46 317
408	T. 17N - R. 36E	296 47 249	72 35 37	368 82 286
169	T. 17N - R. 37E	--	--	--
496	T. 16N - R. 34E	-- -- --	698 96 602	698 96 602
656	T. 16N - R. 35E	568 17 551	16 -- 16	584 17 567
116	T. 16N - R. 36E	--	--	--
106	T. 16N - R. 37E	-- -- --	104 -- 104	104 -- 104

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 10:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Present Use: Class II	Cropland - red Rangeland - green Class III	Total
896	T. 17N - R. 38E	611 175 436	504 -- 504	1,115 175 940
365	T. 17N - R. 39E	--	--	--
330	T. 17N - R. 40E	--	--	--
372	T. 17N - R. 41E	-- -- --	242 160 82	242 160 82
699	T. 16N - R. 38E	138 43 95	86 -- 86	224 43 181
560	T. 16N - R. 39E	152 1 151	88 -- 88	240 1 239
2,391	T. 16N - R. 40E	-- -- --	37 37 --	37 37 --
5,164	T. 16N - R. 41E	440 147 293	397 22 375	837 169 668

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 11:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use: Total Cropland	Legal Description	Potentially Irrigable Land (Acres) — Present Use: Cropland - red, Rangeland - green: Class II	Class III	Total
911	T. 17N - R. 42E	50	133	183
		21	36	57
		29	97	126
2,869	T. 17N - R. 43E	232	2,539	2,771
		141	1,149	1,290
		91	1,390	1,481
4,908	T. 16N - R. 42E	98	--	98
		78	--	78
		20	--	20
3,001	T. 16N - R. 43E	1,814	735	2,549
		873	43	916
		941	692	1,633
1,727	T. 16N - R. 44E	--	--	--

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 12:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use: Cropland - red Rangeland - green		
Total Cropland	Legal Description	Class II	Class III	Total
238	T. 15N - R. 30E	-- -- --	704 85 619	704 85 619
149	T. 15N - R. 31E	--	--	--
535	T. 15N - R. 32E	--	--	--
1,942	T. 15N - R. 33E	--	--	--
580	T. 15N - R. 34E	312 23 289	211 -- 211	523 23 500
356	T. 14N - R. 30E	-- -- --	702 160 542	702 160 542
--	T. 14N - R. 31E	--	--	--
--	T. 14N - R. 32E	--	--	--
--	T. 14N - R. 33E	--	--	--
--	T. 14N - R. 34E	--	--	--
--	T. 13N - R. 30E	-- -- --	475 -- 475	475 -- 475
--	T. 13N - R. 31E	--	--	--
--	T. 13N - R. 32E	--	--	--
--	T. 13N - R. 33E	--	--	--
--	T. 13N - R. 34E	--	--	--

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 13:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use:	Cropland - red Rangeland - green	
Total Cropland	Legal Description	Class II	Class III	Total
--	T. 15N - R. 35E	232	--	232
		--	--	--
		232	--	232
--	T. 15N - R. 36E	224	187	411
		--	--	--
		224	187	411
--	T. 15N - R. 37E	--	--	--
523	T. 15N - R. 38E	--	--	--
8	T. 15N - R. 39E	--	--	--
501	T. 14N - R. 35E	231	197	428
		--	--	--
		231	198	428
--	T. 14N - R. 36E	--	--	--
--	T. 14N - R. 37E	--	--	--
425	T. 14N - R. 38E	--	--	--
56	T. 14N - R. 39E	--	302	302
		--	--	--
		--	302	302
216	T. 13N - R. 35E	--	--	--
--	T. 13N - R. 36E	--	--	--
--	T. 13N - R. 37E	--	--	--
--	T. 13N - R. 38E	--	--	--
--	T. 13N - R. 39E	--	--	--

ENUMERATIVE DATA FOR GARFIELD COUNTY PLATE 14:1
POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Present Use: Cropland - red; Rangeland - green

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Class II	Class III	Total
1,146	T. 15N - R. 40E	--	579	579
		--	185	185
		--	394	394
1,380	T. 15N - R. 41E	86	614	700
		72	21	93
		14	593	607
181	T. 15N - R. 42E	--	790	790
		--	--	--
		--	790	790
153	T. 15N - R. 43E	--	402	402
		--	--	--
		--	402	402
2,719	T. 15N - R. 44E	133	--	133
		75	--	75
		58	--	58
--	T. 14N - R. 40E	--	--	--
3,255	T. 14N - R. 41E	--	1,126	1,126
		--	1,030	1,030
		--	96	96
3,134	T. 14N - R. 42E	--	377	377
		--	243	243
		--	134	134
566	T. 14N - R. 43E	--	--	--
1,602	T. 14N - R. 44E	--	--	--
--	T. 13N - R. 40E	--	--	--
178	T. 13N - R. 41E	--	--	--
3,783	T. 13N - R. 42E	--	496	496
		--	348	348
		--	148	148
2,696	T. 13N - R. 43E	--	--	--
3,411	T. 13N - R. 44E	--	88	88
		--	58	58
		--	30	30

MCCONE COUNTY ENUMERATIVE DATA ON
POTENTIALLY IRRIGATED LAND - PRESENT LAND USE
FOR ALL 10 SUB-AREAS OF MCCONE COUNTY

ENUMERATIVE DATA FOR MCCONE COUNTY PLATE 1:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use:	Cropland - red Rangeland - green	
Total Cropland	Legal Description	Class II	Class III	Total
556	T. 27N - R. 41E	757 475 282	22 12 10	779 487 292
--	T. 27N - R. 42E	--	--	--
104	T. 26N - R. 41E	-- -- --	66 5 61	66 5 61
398	T. 26N - R. 42E	--	--	--
1,243	T. 26N - R. 43E	845 613 232	626 143 483	1,471 756 715
2,841	T. 26N - R. 44E	3,752 2,420 1,332	779 275 504	4,531 2,695 1,836
1,882	T. 26N - R. 45E	29 10 19	2,619 765 1,854	2,648 775 1,873
357	T. 25N - R. 42E	--	--	--
342	T. 25N - R. 43E	--	--	--
4,137	T. 25N - R. 44E	--	--	--
3,067	T. 25N - R. 45E	-- -- --	878 357 521	878 357 521

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use:	Cropland Rangeland	-red -green
Total Cropland	Legal Description	Class II	Class III	Total
--	T. 27N - R. 46E	--	--	--
2,576	T. 27N - R. 47E	797	3,411	4,208
		575	1,937	2,512
		222	1,474	1,696
2,444	T. 27N - R. 48E	80	2,635	2,715
		80	1,706	1,786
		--	929	929
3,860	T. 27N - R. 49E	197	1,107	1,304
		115	901	1,016
		82	206	288
4,214	T. 27N - R. 50E	2,566	888	3,454
		1,276	537	1,813
		1,290	351	1,641
7,027	T. 26N - R. 46E	330	4,104	4,434
		238	2,832	3,070
		92	1,272	1,364
6,530	T. 26N - R. 47E	443	1,527	1,970
		199	1,152	1,351
		244	375	619
11,929	T. 26N - R. 48E	--	2,856	2,856
		--	2,387	2,387
		--	469	469
10,166	T. 26N - R. 49E	--	3,162	3,162
		--	1,828	1,828
		--	1,334	1,334
9,211	T. 26N - R. 50E	182	2,894	3,076
		30	2,234	[illegible]
		152	660	812
5,324	T. 25N - R. 46E	--	798	798
		--	[illegible]	[illegible]
		--	69	69
5,182	T. 25N - R. 47E	--	450	450
		--	159	[illegible]
		--	291	291
11,031	T. 25N - R. 48E	--	406	406
		--	[illegible]	[illegible]
		--	60	60
15,353	T. 25N - R. 49E	--	1,730	1,730
		--	1,406	1,406
		--	324	324
9,532	T. 25N - R. 50E	--	2,950	2,950
		--	1,848	1,848
		--	1,102	1,102

ENUMERATIVE DATA FOR MCCONE COUNTY PLATE 3:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use: Cropland - red, Rangeland - green		
Total Cropland	Legal Description	Class II	Class III	Total
367	T. 24N - R. 43E	--	--	--
1,274	T. 24N - R. 44E	--	--	--
1,670	T. 24N - R. 45E	29	998	1,027
		28	315	343
		1	683	684
2,720	T. 24N - R. 46E	48	203	251
		12	174	186
		36	29	65
2,146	T. 23N - R. 43E	--	331	331
		--	166	166
		--	165	165
1,214	T. 23N - R. 44E	--	--	--
1,876	T. 23N - R. 45E	627	206	833
		211	132	343
		416	74	490
2,876	T. 23N - R. 46E	448	424	872
		235	251	486
		213	173	386

ENUMERATIVE DATA FOR MCCONE COUNTY PLATE 4:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Present Use: Class II	Cropland - red Rangeland - green Class III	Total
7,553	T. 24N - R. 47E	341 207 134	488 311 177	829 518 311
11,427	T. 24N - R. 48E	117 38 79	634 249 385	751 287 464
15,326	T. 24N - R. 49E	-- -- --	2,712 2,045 667	2,712 2,045 667
9,907	T. 24N - R. 50E	483 130 353	3,917 2,869 1,048	4,400 2,999 1,401
8,670	T. 23N - R. 47E	-- -- --	532 358 174	532 358 174
15,902	T. 23N - R. 48E	80 48 32	2,485 1,925 560	2,565 1,973 592
16,133	T. 23N - R. 49E	-- -- --	672 581 91	672 581 91

ENUMERATIVE DATA FOR MCCONE COUNTY PLATE 5:1
POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use:	Cropland - red Rangeland - green	
Total Cropland	Legal Description	Class II	Class III	Total
438	T. 22N - R. 43E	--	--	--
462	T. 22N - R. 44E	--	--	--
3,940	T. 22N - R. 45E	1,915 1,527 388	87 71 16	2,002 1,598 404
2,953	T. 22N - R. 46E	437 284 153	142 70 72	579 354 225
17	T. 21N - R. 43E	--	--	--
2,498	T. 21N - R. 44E	-- -- --	464 129 335	464 129 335
4,601	T. 21N - R. 45E	210 163 47	1,350 1,039 311	1,560 1,202 358
5,282	T. 21N - R. 46E	162 93 69	153 54 99	315 147 168

ENUMERATIVE DATA FOR MCCONE COUNTY PLATE 6:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Present Use: Class II	Cropland - red Rangeland - green Class III	Total
15,682	T. 22N - R. 47E	398	576	974
		358	437	795
		40	139	179
12,246	T. 22N - R. 48E	--	866	866
		--	311	311
		--	555	555
6,817	T. 22N - R. 49E	--	781	781
		--	499	499
		--	282	282
15,070	T. 21N - R. 47E	319	43	362
		214	--	214
		105	43	148
16,803	T. 21N - R. 48E	--	810	810
		--	505	505
		--	305	305
8,231	T. 21N - R. 49E	--	205	205
		--	141	141
		--	64	64

ENUMERATIVE DATA FOR MCCONE COUNTY PLATE 7:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use:	Cropland - red Rangeland - green	
Total Cropland	Legal Description	Class II	Class III	Total
270	T. 20N - R. 43E	-- -- --	162 47 115	162 47 115
215	T. 20N - R. 44E	--	--	--
1,181	T. 20N - R. 45E	--	--	--
7,211	T. 20N - R. 46E	272 187 85	387 210 177	659 397 262
240	T. 19N - R. 43E	118 12 106	-- -- --	118 12 106
1,150	T. 19N - R. 44E	739 208 531	-- -- --	739 208 531
3,907	T. 19N - R. 45E	232 -- 232	--- -- --	232 -- 232
11,234	T. 19N - R. 46E	67 58 9	715 288 427	782 346 436

ENUMERATIVE DATA FOR MCCONE COUNTY PLATE 8:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Present Use: Class II	Cropland - red Rangeland - green Class III	Total
12,763	T. 20N - R. 47E	683 254 429	64 20 44	747 274 473
13,472	T. 20N - R. 48E	218 121 97	1,048 699 349	1,266 820 446
5,931	T. 20N - R. 49E	-- -- --	899 295 604	899 295 604
10,043	T. 19N - R. 47E	229 109 120	72 -- 72	301 109 192
7,836	T. 19N - R. 48E	634 397 237	2,893 1,599 1,294	3,527 1,996 1,531
6,990	T. 19N - R. 49E	312 237 75	779 492 287	1,091 729 362

ENUMERATIVE DATA FOR MCCONE COUNTY PLATE 9:1
POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use Total Cropland	Legal Description	Potentially Irrigable Irrigable Land (Acres) Present Use: Cropland - red, Rangeland - green Class II	Class III	Total
2,569	T. 18N - R. 44E	210 33 177	-- -- --	210 33 177
6,705	T. 18N - R. 45E	186 95 91	34 10 24	220 105 115
10,344	T. 18N - R. 46E	-- -- --	1,472 1,056 416	1,472 1,056 416
3,551	T. 17N - R. 45E	82 30 52	-- -- --	82 30 52
7,916	T. 17N - R. 45E	134 67 67	-- -- --	134 67 67
11,879	T. 17N - R. 46E	1,688 1,267 421	2,819 1,698 1,121	4,507 2,965 1,542
9,401	T. 16N - R. 46E	958 723 235	2,279 1,749 530	3,237 2,472 765

ENUMERATIVE DATA FOR MCCONE COUNTY PLATE 10:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use Total Cropland	Legal Description	Potentially Irrigable Land (Acres) Present Use: Class II	Cropland -red Rangeland -green Class III	Total
8,444	T. 18N - R. 47E	2,208	238	2,446
		1,294	74	1,368
		914	164	1,078
5,428	T. 18N - R. 48E	642	496	1,138
		434	224	658
		208	272	480
4,219	T. 18N - R. 49E	954	433	1,387
		291	142	433
		663	291	954
4,807	T. 17N - R. 47E	360	854	1,214
		210	492	702
		150	362	512
4,463	T. 17N - R. 48E	189	1,389	1,578
		119	1,083	1,202
		70	306	376
4,811	T. 17N - R. 49E	219	722	941
		144	586	730
		75	136	211

DAWSON-RICHLAND COUNTIES ENUMERATIVE DATA ON POTENTIALLY IRRIGATED LAND - PRESENT LAND USE FOR ALL 4 SUB-AREAS OF DAWSON-RICHLAND COUNTIES

ENUMERATIVE DATA FOR DAWSON-RICHLAND COUNTIES PLATE 1:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Present Use: Class II	Cropland - red / Rangeland - green Class III	Total
NA	T. 28N - R. 53E[1]	--	--	--
NA	T. 27N - R. 51E[1]	--	--	--
NA	T. 27N - R. 52E[1]	-- -	--	--
NA	T. 27N - R. 53E[1]	--	--	--
NA	T. 27N - R. 54E[1]	--	--	--
8,004	T. 26N - R. 51E	--	1,213	1,213
		--	1,148	1,148
		--	65	65
NA	T. 26N - R. 52E[1]	--	--	--
NA	T. 26N - R. 53E[1]	--	--	--
NA	T. 26N - R. 54E[1]	--	--	--

[1] Data unavailable at time of tabulation.

ENUMERATIVE DATA FOR DAWSON-RICHLAND COUNTIES PLATE 2:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
Total Cropland	Legal Description	Present Use: Class II	Cropland - Rangeland - green Class III	Total
7,624	T. 25N - R. 51E	--	1,509	1,509
		--	248	248
6,472	T. 25N - R. 52E	99	291	390
		15	189	204
8,826	T. 25N - R. 53E	88	851	939
		73	244	317
NA	T. 25N - R. 54E[1]	--	--	--
3,840	T. 24N - R. 51E	64	1,270	1,334
		64	378	442
4,390	T. 24N - R. 52E	395	382	777
		113	177	290
6,963	T. 24N - R 53E	662	896	1,558
		387	155	542
11,847	T. 24N - R. 54E	334	1,837	2,171
		54	248	302

[1] Data unavailable at the time of tabulation.

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use: Cropland - [illegible] Rangeland - green		
Total Cropland	Legal Description	Class II	Class III	Total
9,793	T. 23N - R. 50E	2,531	7,026	9,557
		[illegible]	5,891	7,043
		1,379	1,135	2,514
10,331	T. 23N - R. 51E	864	2,907	3,771
		604	2,115	[illegible]
		260	792	1,052
7,990	T. 23N - R. 52E	--	771	771
		--	612	612
		--	159	159
8,697	T. 23N - R. 53E	213	1,245	1,458
		179	1,003	1,182
		34	242	276
13,096	T. 23N - R. 54E	221	307	528
		137	264	[illegible]
		84	43	127
2,580	T. 22N - R. 50E	3,280	6,013	9,293
		334	2,070	[illegible]
		2,946	3,943	6,889
9,093	T. 22N - R. 51E	1,510	7,042	8,552
		992	4,270	5,262
		518	2,772	3,290
11,312	T. 22N - R. 52E	--	--	--
2,522	T. 22N - R. 53E	64	1,238	1,302
		15	515	530
		49	723	772
3,315	T. 22N - R. 54E	1,005	645	1,650
		675	317	[illegible]
		330	328	658
6,130	T. 21N - R. 50E	4,011	3,455	7,466
		1,515	2,289	[illegible]
		2,496	1,166	3,662
8,121	T. 21N - R. 51E	3,370	5,770	9,140
		1,931	[illegible]	[illegible]
		1,439	1,778	3,217
8,469	T. 21N - R. 52E	--	--	--
3,581	T. 21N - R. 53E[1]	--	--	--

[1] Data for the southwestern area of the township was not available at the time of tabulation. The cropland acreage is from the northwest portion.

ENUMERATIVE DATA FOR DAWSON-RICHLAND COUNTIES PLATE 4:1

POTENTIALLY IRRIGABLE LAND & PRESENT LAND USE

Existing Land Use		Potentially Irrigable Land (Acres)		
		Present Use:	Cropland - red Rangeland - green	
Total Cropland	Legal Description	Class II	Class III	Total
3,557	T. 20N - R. 50E	2,075 706 1,369	7,154 2,202 4,952	9,229 2,908 6,321
742	T. 20N - R. 51E	--	--	--
1,779	T. 20N - R. 52E[1]	--	--	--
NA	T. 20N - R. 53E[2]	--	--	--
7,055	T. 19N - R. 50E	1,197 657 540	8,979 5,279 3,700	10,176 5,936 4,240
1,145	T. 19N - R. 51E[1]	--	--	--
NA	T. 19N - R. 52E[2]	--	--	--
3,828	T. 18N - R. 50E	--	--	--
NA	T. 18N - R. 51E[2]	--	--	--

[1] Data for the southwestern area of the township was not available at the time of tabulation. The cropland acreage is from the northwestern portion.

[2] Data unavailable at the time of tabulation.

CHAPTER IV

COAL RESOURCES AND DEVELOPMENT POTENTIAL

COAL RESOURCES AND DEVELOPMENT POTENTIAL

A. COAL AVAILABILITY

Introduction

Much of eastern Montana, including parts of McCone, Dawson, Richland and Garfield Counties is underlain by the Fort Union Formation, which in Montana contains coal beds in three members: the Tullock, Lebo and Tongue River Members. The total Fort Union Formation area, extending into western North Dakota, northwestern South Dakota, northeastern Wyoming and southeastern Saskatchewan is termed the Fort Union coal region This region contains over a trillion tons of reserves of lignite and subbituminous coal within 3,000 feet of the surface (Averitt, 1968), the largest coal region in the world. Figure IV-1 shows an outline of the Fort Union Coal Area and the Proposed East Central Water Conservancy District

In terms of future development, however, only the lower-cost subbituminous coal and lignite mineable by surface methods in the Fort Union region will likely be utilized. (Under the classification system of the American Society for Testing Materials, coal with a calorific value from 6,300 to 8,300 BTU per pound on a moist-mineral-matter-free basis is ranked lignite. Coal with calorific value from 8,300 to 9,500 BTU is ranked as subbituminous C, and coal from 9,500 to 10,500 is classified as subbituminous B). Total strippable reserves of lignite and subbituminous coal in Montana, Wyoming and North Dakota have been estimated at 78 billion tons. Montana's strippable reserves of 18 billion tons consist of both subbituminous coal and lignite, of which the subbituminous reserves make up the larger portion of the total. In North Dakota, with estimated strippable reserves at 50 billion tons, all of the reserves are lignite. In Wyoming most of the 10 billion tons of strippable reserves are subbituminous (Averitt, 1968). Figure IV-1 referred to above, shows the occurrence of strippable coal in the Fort Union region of eastern Montana in addition to the relative boundary of lignite and subbituminous coal areas.

Coal Availability in Proposed Water Conservancy District

The strippable coal available in the proposed Water Conservancy District is lignite, and the strippable areas are shown on Figure IV-1. The total estimated strippable lignite reserves of the district is estimated at 2,307 million tons The strippable areas include the Weldon-Timber Creek

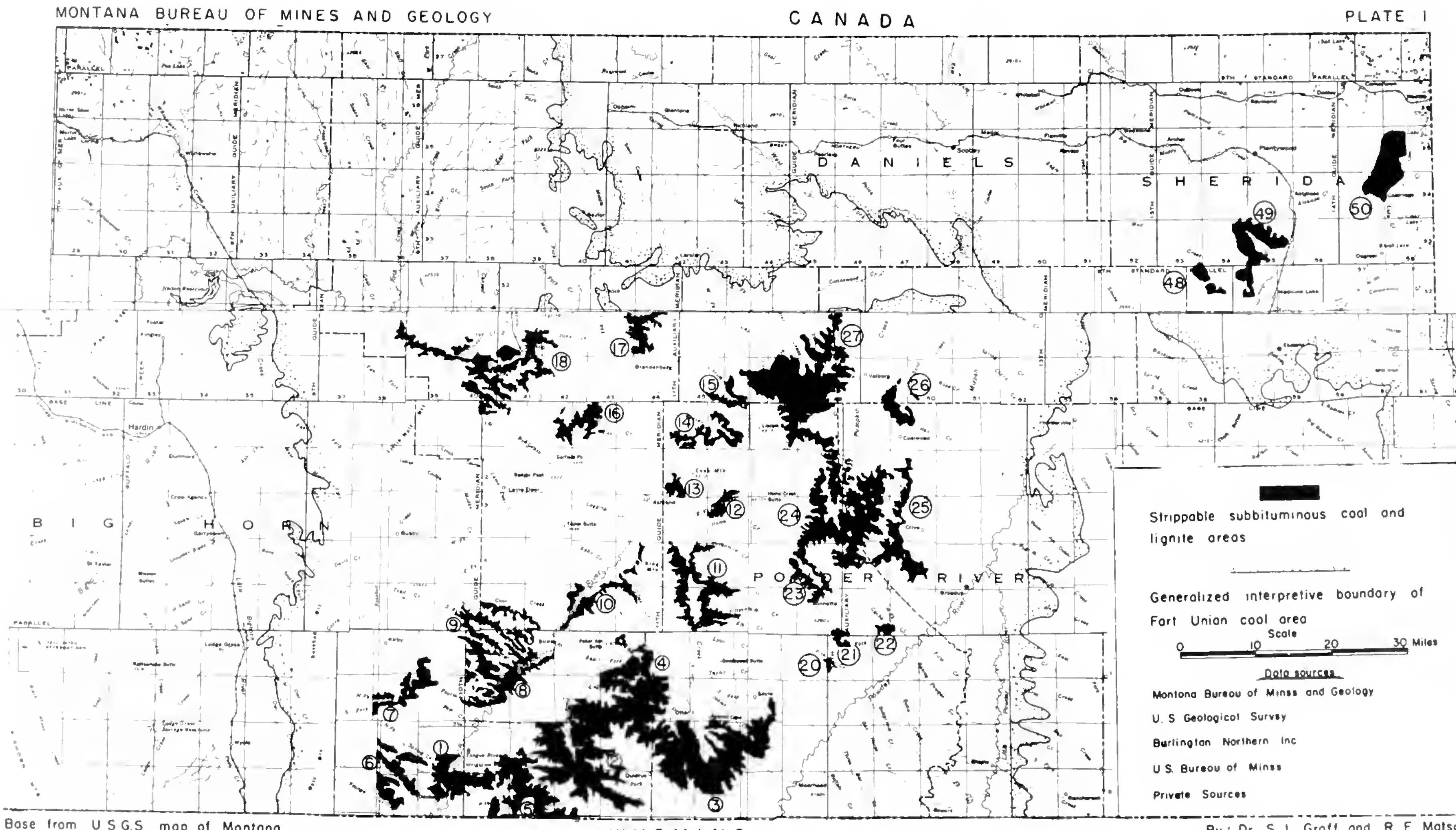


Figure IV-1 - Fort Union Coal Area & the Proposed East Central Montana Water Conservancy District.

MONTANA BUREAU OF MINES AND GEOLOGY

PLATE I

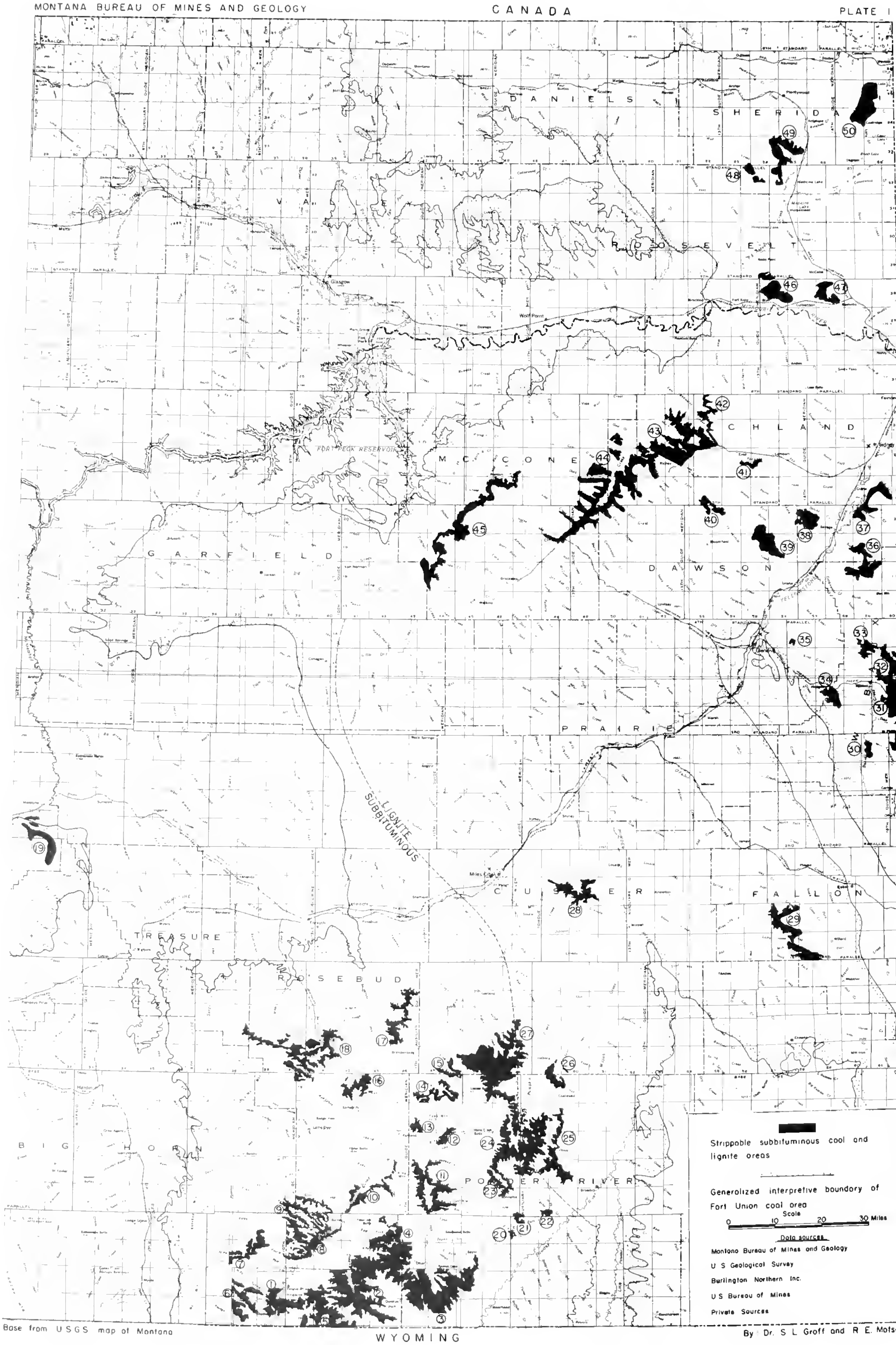


Figure IV-1 - Fort Union Coal Area & the Proposed East Central Montana Water Conservancy District.

deposit (Matson, 1970), the Redwater Creek deposit (Matson, 1970), the Carroll deposit (Ayler, Smith, and Deutman, 1969), the Lane deposit (Ayler, Smith and Deutman, 1969), and small areas in Garfield County (Mowat, 1970). Available analytical data of the various coal deposits are shown on Tables IV-A, IV-B and IV-C.

Weldon-Timber Creek Field

The Weldon-Timber Creek field extends from approximately one and one-half miles south of Weldon in Section 12, T21N, R45E, southeast to T18N, R44E, along the valley of Timber Creek (Figure IV-2, No. 45). The topography of this area ranges from rolling to rough and includes areas of deeply incised drainages and steep-sided buttes. The S coal bed underlying the area has burned, forming prominent, brightly colored clinker at the western edge of the deposit. In general, the strippable coal area is confined by the burned area on the west and by a 150-foot overburden limit line to the east. The width of the strippable coal area ranges from one-half to two miles. Several prominent east-west drainages have created broader local strippable areas, such as in T20N, R45E.

The S bed is 12 feet thick in the northernmost part of the field. It thickens to 20 feet in Section 16, T20N, R45E, and again thins to 8 feet in Section 16, T18N, R44E. The R bed, 50 feet above the S bed in T18 and 19N, R44E, has a thickness of six to eight feet and could be strip mined in some places, but its reserves are not included in this report. Data on the quality of the lignite is shown on Tables IV-A, IV-B and IV-C under drill hole numbers S McC-9, S McC-11 and S McC-12.

The indicated strippable reserves in the Weldon-Timber Creek area total 724 million, of which 345 million tons could be mined in the approximate center of the field in T20N, R45E, the southeast corner of T20N, R44E, and the northwest corner of T19N, R45E.

Redwater Deposit

The strippable part of the Redwater deposit is confined to the low valley sides along Redwater Creek and near the mouth of Horse Creek. Rapidly increasing overburden makes strip mining impractical more than three miles northwest of Circle. Along Redwater Creek, northeast of Circle, the S bed is below creek level almost to the Stephensen

deposit (Matson, 1970), the Redwater Creek deposit (Matson, 1970), the Carroll deposit (Ayler, Smith, and Deutman, 1969), the Lane deposit (Ayler, Smith and Deutman, 1969), and small areas in Garfield County (Mowat, 1970). Available analytical data of the various coal deposits are shown on Tables IV-A, IV-B and IV-C.

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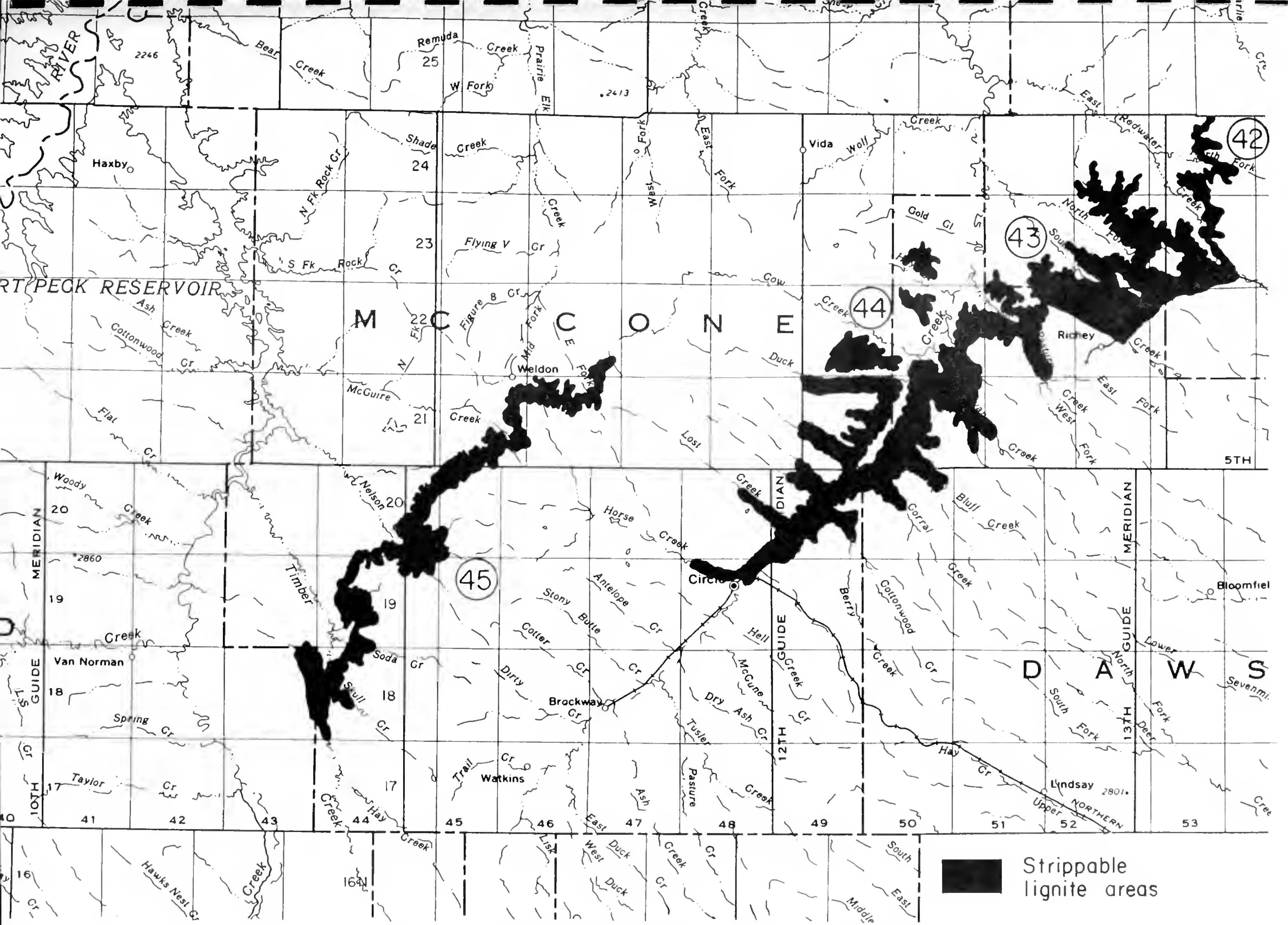


Figure IV-2 - Strippable lignite in proposed Water Conservancy District
McCone, Garfield, Richland and Dawson Counties, Montana

TABLE IV-A
PROXIMATE AND ULTIMATE COAL ANALYSES*

Drill hole no. & location	U.S. Bur. Mines lab Sample no.	2	Mois-ture	Volatile Matter	Fixed Carbon	Ash	S	H	C	N	O	Heat Value (BTU/lb.)
S McC-9	J-10014	A	29.9	27.5	36.9	5.7	0.2	6.1	46.3	0.7	41.2	7,520
NW¼NW¼ Sec.36,		B		39.3	52.6	8.1	0.3	4.0	66.1	1.1	20.4	10,730
T21N, R45E		C		42.7	57.3		0.3	4.3	72.0	1.2	22.2	11,680
S McC-11	J-10015	A	30.5	27.7	35.9	5.9	0.6	6.2	46.6	0.8	39.9	7,660
SW¼NW¼SW¼ Sec.16,		B		39.8	51.7	8.5	0.9	4.1	67.1	1.1	18.3	11,020
T18N, R44E		C		43.5	56.5		1.0	4.4	73.3	1.2	20.1	12,040
S McC-12	J-10016	A	31.7	27.2	35.0	6.1	0.4	6.3	45.2	0.7	41.3	7,400
SW¼SW¼SW¼ Sec. 16,		B		39.9	51.2	8.9	0.6	4.1	66.2	1.1	19.1	10,840
T19N, R44E		C		43.8	56.2		0.6	4.5	72.7	1.2	21.0	11,890
S McC-16	J-10017	A	31.6	24.8	32.9	10.7	0.2	5.9	42.0	0.7	40.5	6,750
SW¼SW¼ Sec.2,		B		36.2	48.1	15.7	0.3	3.5	61.4	1.0	18.1	9,860
T19N, R48E		C		43.0	57.0		0.3	4.1	72.9	1.2	21.5	11,690
Sec. 1, T20N,	I-57171	A	36.4	25.0	31.8	6.8	0.3	6.4	41.1	0.8	44.6	6,610
R49E Stephensen		B		39.3	50.0	10.7	0.4	3.7	64.7	1.3	19.2	10,390
Mine		C		44.1	55.9		0.5	4.1	72.4	1.4	21.6	11,630
Sec. 8 T22N		A	33.0	25.5	36.0	5.5	0.3					7,400
R51E, Carroll		B		38.1	53.7	8.2	0.5					11,050
Mine		C		41.5	58.5		1.6					12,030
Sec. 26 T23N		A	36.5	26.9	30.0	6.6	0.9					7,150
R53E, Lane		B		42.4	47.2	10.4	1.4					11,250
Mine		C		47.4	52.6		1.5					12,560

*Source: Preliminary Report Strippable Coal Resources, McCone County by Robert E. Matson.
Strippable Coal Resources of Montana by Ayler, Smith and Deutman.

[2]Form of Analyses: A - as received; B - moisture free; C - moisture and ash free.

TABLE IV-B

ASH FUSIBILITY, S COAL BED*

Bed	Drill Hole No.	U.S. Bur. Mines lab no.	Ash Fusibility, °F Initial Deformation Temperature	Softening Temperature	Fluid Temperature
S	S McC-9	J-1114	2480	2520	2560
S	S McC-11	J-10015	2170	2220	2270
S	S McC-12	J-10016	2080	2180	2260
S	S McC-16	J-10017	2060	2100	2140

TABLE IV-C
ANALYSES OF ASH, S COAL BED

Drill Hole No.	S McC-9	S McC-11	S McC-12	S McC-16
U.S. Bureau Mines lab no.	J-10014	J-10015	J-10016	J-10017
SiO_2	23.5	6.9	21.8	51.9
Al_2O_3	11.5	4.6	11.1	12.6
Fe_2O_3	4.0	14.4	7.1	2.3
FeO	.20	.20	.20	.20
MgO	11.4	6.9	6.8	4.8
CaO	36.5	27.1	23.6	13.3
Na_2O	1.7	4.8	7.0	5.2
K_2O	.47	.67	1.2	1.9
H_2O-	.12	.04	.02	.03
H_2O+	.58	.63	.60	.83
TiO_2	.42	.18	.46	.52
P_2O_5	.11	.08	.42	.26
MnO	.09	.12	.17	.09
CO_2	.38	<.05	<.05	.19
S as SO_3		33.2	18.0	6.2
TOTAL	100	100	99	100

*Source: Preliminary Report Strippable Coal Resources, McCone County, Montana, by Robert E. Matson

Notes: Analyses by U.S. Geol. Survey, Washington, D.S. using methods described in U.S. Geol. Survey Bulletin 1144-A, supplemented by atomic absorption.

mine, in Section 1, T20N, R49E, where it is a few feet above creek level. (Figure IV-2, No. 44) North of the Stephensen mine, the S bed crops out along the sides of the valleys of Redwater Creek and its tributaries.

The S bed decreases in thickness from south to north. Its maximum thickness is 21 feet in Section 2, T19N, R48E. The thickness decreases to 7 feet 11 inches in Section 6, T21N, R49E, along Duck Creek. Other factors, however, may favor development of the northern part of the field where there is no drainage problem nor any need to divert streams. There, too, the value of the surface is lower. Analytical data on the S coal bed is shown on Table IV-A under drill hole S McC-16 and the Stephensen mine. Ash fusibility and analysis for hole S McC-16 are shown on Tables IV-B and IV-C respectively.

The strippable reserves of the Redwater deposit total 642 million tons under a maximum overburden thickness of 150 feet. Additional field work, supplemented by drilling, should increase the reserves appreciably.

Carroll Deposit

The Carroll deposit is a northeastward continuation of the Redwater deposit described above and is located in T20,21, 22 and 23N, R50 and 51E in Dawson and Richland Counties (Figure IV-2, No. 43). The Carroll bed is the same coal bed as the S coal bed described in the Redwater deposit. The average thickness of the Carroll bed is 6.5 feet with a total reserve estimated at 345.4 million tons. An analysis from the Carroll mine located in Section 8, T22N, R51E is shown on Figure IV-2 (Ayler, Smith and Deutman, 1969, p. 50 and 51).

Lane Deposit

The Lane coal deposit straddles the Richland-Dawson County line in T22, 23 and 24N, R51, 52 and 53E (Figure IV-2, No. 42). The measured thickness of the Lane coal bed varies from 2.5 to 9.5 feet with an average thickness of seven feet. The total inferred reserve is 561.5 million tons. An analysis of the Lane coal bed taken from the Lane mine, located in Section 26, T23N, R53E, is shown on Table IV-A (Ayler, Smith and Deutman, 1969, p. 51).

Garfield County

Very little information on the occurrence of coal in Garfield County is available at this time. The United States Geological Survey Mineral Classification Branch has

been conducting a survey in the county for a number of years; however, no information has been published. According to George Mowat (U.S.G.S. personal communication), there are two small potential strippable areas west of Jordan with reserves of about five million tons each underlain by coal beds with measured thicknesses of five feet. In addition, six to ten miles northeast of Jordan two strippable coal deposits occur with each having potential reserves of 20 to 25 million tons underlain by coal beds with measured thicknesses of five and six feet. Other areas with potential occur approximately 18 miles northeast of Jordan and in the extreme eastern part of Garfield County adjoining the southern part of the Weldon-Timber Creek deposit in T17N, R43E and T16N, R44E. No analytical data on Garfield County coal is currently available.

Factors Restricting Development to Date

The coal resources occurring within the proposed Conservancy District, as well as other areas in eastern Montana, have not been developed due to long distances from large market areas. In addition, availability of natural gas in the State rapidly curtailed domestic coal markets following World War II. Population declines, coupled with lack of industrial markets, further curtailed power needs in eastern Montana, while western Montana's power needs were supplied by hydro sources. It has only been in the last few years that the Fort Union coal region has been looked upon as a potential supplier of power and fuels.

B. DEVELOPMENT POTENTIAL

Introduction

The development potential of eastern Montana and the area included in the proposed Water Conservancy District are enormous when viewed over the next 30-year period. The development which will likely occur will include both synthetic fuels and chemicals and a related power generation industry. The power generation industry would utilize coal and by-product char from synthetic fuel plants and could be tied to both Mid-western and West Coast markets by extra-high-voltage (E.H.V.) transmission lines or super conductors.

Utilization of coal in the Fort Union coal region is a

logical way to meet much of the nation's future power and fuel requirement; however, a great deal of research, pilot plant operation, planning and coordination remains to be done. Research underway required to optimize development of the Fort Union coal region includes the development of economic processes for producing synthetic fuels, development of the MHD generator, development of transportation networks for moving large blocks of power through extra-high-voltage (E.H.V.) lines or super conductors and development of transporation systems for moving synthetic fuels to market.

National growth in electric power consumption requiring doubling of capacity every ten years, due to restrained population growth to doubling every twelve years, presents a tremendous market for eastern Montana coal. To the energy planners of private industry, public utilities, power cooperatives, and Federal agencies it poses a tremendous challenge -- that of supplying distant markets from an area until now considered to be remote. In the long run, however, the vast coal deposits may prove to be strategically located halfway between the large markets of the Mid-west and West Coast.

The United States coal reserves are much greater than the reserves of petroleum and natural gas. In fact, the recoverable coal determined by mapping and exploration is over 30 times the energy content of petroleum and natural gas combined, making coal a very attractive material for supplementing fluid fuels (Cameron, 1970). The largest uncommitted coal reserves are in the Fort Union coal region in Montana, Wyoming and North Dakota.

<u>Synthetic Fuels</u>

A large research effort is underway by private industry and Federal agencies in finding economic processes for producing synthetic fuels from coal. The reason for this effort is the fact that the proved reserves of petroleum and natural gas are only sufficient to supply the needs of the United States for less than 15 years at the current rate of consumption (Cameron, 1970).

The natural gas situation in areas of the United States is very critical, and cost estimates of producing synthetic pipeline gas from coal is now competitive with natural gas in some populated areas of the Mid-west and East. The Institute of Gas Technology predicts that the first commercial

synthetic gas plant will be built in the mid 1970's, following successful operation of its high pressure gasification pilot plant on which construction was completed in June, 1970. I.G.T. has been investigating high pressure gasification of coal since the mid 1950's and has received funding from the Office of Coal Research in construction of the pilot plant. Design of the first deomonstration plant is under contract, and a study to identify gasification plant sites throughout the nation has been completed. It is anticipated the first deomonstration plant could be completed in 1974 (Office of Coal Research, 1970).

Another system for gasification of coal of importance to Montana and the proposed Conservancy District is the CO_2 Acceptor Process, a project developed by Consolidation Coal Company and supported by the Office of Coal Research. A pilot plant is now under construction near Rapid City and programmed to become operational by April, 1971. Montana subbituminous coal and lignite seem to be well suited to this process, which will develop by-product char. The char could be utilized as a fuel in power generation. The basic feature of the CO_2 Acceptor Process is the gasification of coals in the presence of calcined limestone and dolmite which react with CO_2, providing heat for the process and purifying the gas in situ. The product will be a methane rich synthetic gas (OCR, 1970).

Another OCR experimental study on coal gasification is being carried out by Bituminous Coal Research. At West Virginia University, OCR is sponsoring a project on computer optimization of coal gasification processes to integrate, if possible, parts of various gasification systems into more feasible systems.

In coal conversion to liquids, OCR is sponsoring Project Gasoline and Project COED, both of interest to Montana's future development. Project Gasoline, under continuous sponsorship by OCR since 1963 and costs totaling $22,066,650, has been operating for three years, during which time it has been plagued by mechanical problems, preventing accumulation of data needed to design a commercial plant (OCR, 1970).

Project COED, developed and under contract by the F.M.C. Corporation, with $9,734,000 OCR participation, is a process for the multi-stage fluidized bed pyrolysis of coal, yielding synthetic crude oil, hydrogen or pipeline gas, and low-sulfur char. A pilot plant utilizing 36 tons of coal per day was completed in 1970 (OCR, 1970). The COED process produces an oil which can be upgraded to

the equivalent of natural crude oil but results in a large quantity of by-product char. A large plant, with a capacity of 30,000 barrels of synthetic crude per year, would produce char to supply the annual requirement of 1,500 megawatt (MW) power plant. Montana subbituminous coal and lignite are suitable for the process, but yields are generally smaller than from higher rank coals. Commercialization of the process could occur by 1977 (Cameron, 1970, P. 31 and 32).

Bench-scale research on coal conversion is being conducted at Montana State University under direction of Dr. Lloyd Berg, Department of Chemical Engineering. Research has been centered upon conversion of subbituminous coal and lignite with and without a catalyst. Private companies which already have production or coal leases in the Fort Union region of Montana, Wyoming, and North Dakota and are involved in developing technology for converting coal to synthetic fuels are Humble Oil Company, Continental Oil Company, Gulf Oil Company, and Peabody Coal Company.

Humble Oil Company, through its research affiliate, Esso Research and Engineering Company, has operated a pilot coal conversion plant at Baytown, Texas, for the last two and one-half years and has been successful in liquefying coal on a continuous basis.

Continental Oil Company, through its subsidiary the Consolidation Coal Company, has been involved in coal conversion for many years. Two of the conversion schemes, one for gasification and one for liquefaction, are currently sponsored by the Office of Coal Research. These are Project Gasoline at Cresop, West Virginia, and the CO_2 Acceptor Process for which a pilot plant is under construction near Rapid City, South Dakota.

Gulf Oil Company acquired the Pittsburg and Midway Coal Company, which was investigating de-ashing through liquefaction.

Peabody Coal Company and Panhandle-Eastern Pipeline Company announced on May 5, 1970, that they would develop a system for gasifying coal.

Electric Power Production and Transmission

Spokesmen for the energy industry state that future conversion plants, as those described above, will need to

take advantage of the economics of scale. For example, a plant for producing a synthetic crude of 100,000 barrels per day will require from 20 to 25 million tons of coal each year (Herrington, 1969, p. 186). The Office of Coal Research visualizes future conversion plants as integrated with power production utilizing by-product char produced from the conversion process (Cockran, 1969, p. 171).

Establishment of large electric power generation centers in the Fort Union coal region inter-ties between the West Coast and Mid-West are a very definite possibility. Walter J. Hickel, former Secretary of the Interior, predicts that a grid of regional high-voltage transmission lines will tie the various sections of the country together by 1980 (*Electric World*, April 20, 1970, p. 171).

Under existing technology, transmission of power from the Fort Union coal region to both the West Coast and Mid-West is feasible, according to the Federal Power Commission (1964) and the Department of Interior (1968) in *Transmission Study 190*. This later report shows that peak power demands between the Mid-West and West Coast are two hours apart, as are the seasonal peaks, allowing transfer of available power from one region to the other to meet demand.

Present coal-fired steam electric power systems operate on an efficiency rating of around 45 percent. In connection with integrated power and coal conversion plants, the Office of Coal Research has received additional funding from Congress to support research on magnetohydrodynamics (M.H.D.). It is believed that power production efficiencies in the 60 percent range can be achieved through M.H.D. For a continuous M.H.D. generator, considerable development work needs to be done. Avco Everett Research Laboratories have developed M.H.D. generators capable of short-time loads and have stated a desire to develop a pilot plant project for a continual M.H.D. generator in Montana, pending availability of OCR funding. The M.H.D. generator would produce direct current, which is necessary for cryogenic cable transmission.

Power can be transmitted by either above-ground (conventional) or by under-ground means. Because of the drawback of above-ground transmission lines, there has been considerable effort to develop under-ground lines that can compete with above-ground lines. Research has concentrated on cryogenic cables. The cryogenic cable consists of a thermally insulated pipeline with a probable diameter of 30 inches, filled with liquid circulating nitrogen, maintained at a temperature between 14-20° K by spaced refrigeration

stations. The current is carried in dual copper wires with cores of superconducting alloys, such as niobium-zirconium (Steinberg, Powell, Manowitz, 1969) and (Groff, 1970).

Current Markets for Coal

Ultimately, development of large power plants inter-tied with the markets of the Mid-West and West Coast will replace the large market developing and being supplied by unit train shipment of Montana's low-sulfur subbituminous coal. This coal is presently being shipped across the lignite fields of North Dakota from the Colstrip area to supply low-sulfur coal to markets as distant as Indiana to reduce sulfur dioxide emission of electric power plants. Another mine development at Decker is planned to supply some of these markets.

As we stated earlier, lignite is a lower rank coal than subbituminous with a lower heating value and a higher moisture content. Therefore, lignite cannot compete favorably in distant markets with subbituminous, and strip mining costs for lignite and subbituminous coal per ton are very close to the same. When calculated on the basis of cost per million BTU, lignite mining costs are higher. Mining costs for 15 strippable coal fields have been calculated, averaging $1.39 per ton on the basis of a 10 million ton per year operation (Matson, Van Voast, and Cameron Engineers, 1970). Using these costs and an average lignite calorific value of 7,000 BTU per pound versus subbituminous at 9,000 BTU per pound, the mining costs of lignite and subbituminous are ten cents and eight cents per million BTU, respectively.

Subbituminous coal has another advantage over lignite--in long-distance transportation. Using the calorific values of lignite and subbituminous above and the cost of moving coal by unit train at four mills per ton mile for a distance of 1,000 miles, lignite transportation costs per million BTU are 29¢ versus 22¢ for subbituminous. Delivered fuel prices are estimated at 39¢ per million BTU for lignite and 30¢ per million BTU for subbituminous.

Subbituminous coal has other advantages over lignite in long-distance transportation, including a lower moisture content, and the fact that it takes more lignite to produce the same heat content as subbituminous. Therefore, more fly ash is produced, and more sulfur dioxide emission occurs.

Since there are large areas of subbituminous coal mineable by strip mining methods, it is not likely that lignite

will compete in supplying distant markets.

Current Leasing Activity

Applications for Federal coal leases on file in the U. S. Bureau of Land Management office in Billings are a good indicator of the areas of interest to major energy companies. Most of the current applications are in areas underlain by subbituminous coal, indicating that immediate interest is for acquisition of BTU or higher rank coal.

Likely Future Coal Based Installation

Future development of a steam power generation industry in the proposed Water Conservancy District will depend on how rapidly technological improvements are made in developing competitive synthetic fuels. For the purposes of this study, it is assumed that sufficient information will be available to permit completion of one conversion plant with an associated electric power production facility by 1980. It is further assumed that national political decisions will be favorable toward developing a synthetic fuel industry and that transportation facilities, power inter-ties for marketing power, and pipelines for synthetic fuels will be available for marketing products.

The advantage of constructing a conversion plant near Fort Peck Reservoir would be the availability of large quantities of water. It is assumed that the plant would be a mine-mouth plant on the Weldon-Timber Creek deposit.

Total mapped strippable reserves (Matson, 1969) in the Weldon-Timber Creek deposit alone would be ample to supply a large conversion plant for a period of 35 years at an annual mining rate of 20 million tons per year.

Size of Coal Based Installations

The present electrical power shortages in many areas of the United States and the forecasts of rapidly increasing demand for electricity indicate a growing market for coal for electrical power generation. Present technology and practices favor conventional coal-steam-electricity power plants for at least ten years. Another electrical power generating process is called magnetohydrodynamics (M.H.D.). A pilot plant utilizing this process may be constructed somewhere in Montana. The process involves the superheating of gas from coal and passing it through an intense magnetic field to produce direct current. It is claimed that the efficiency should

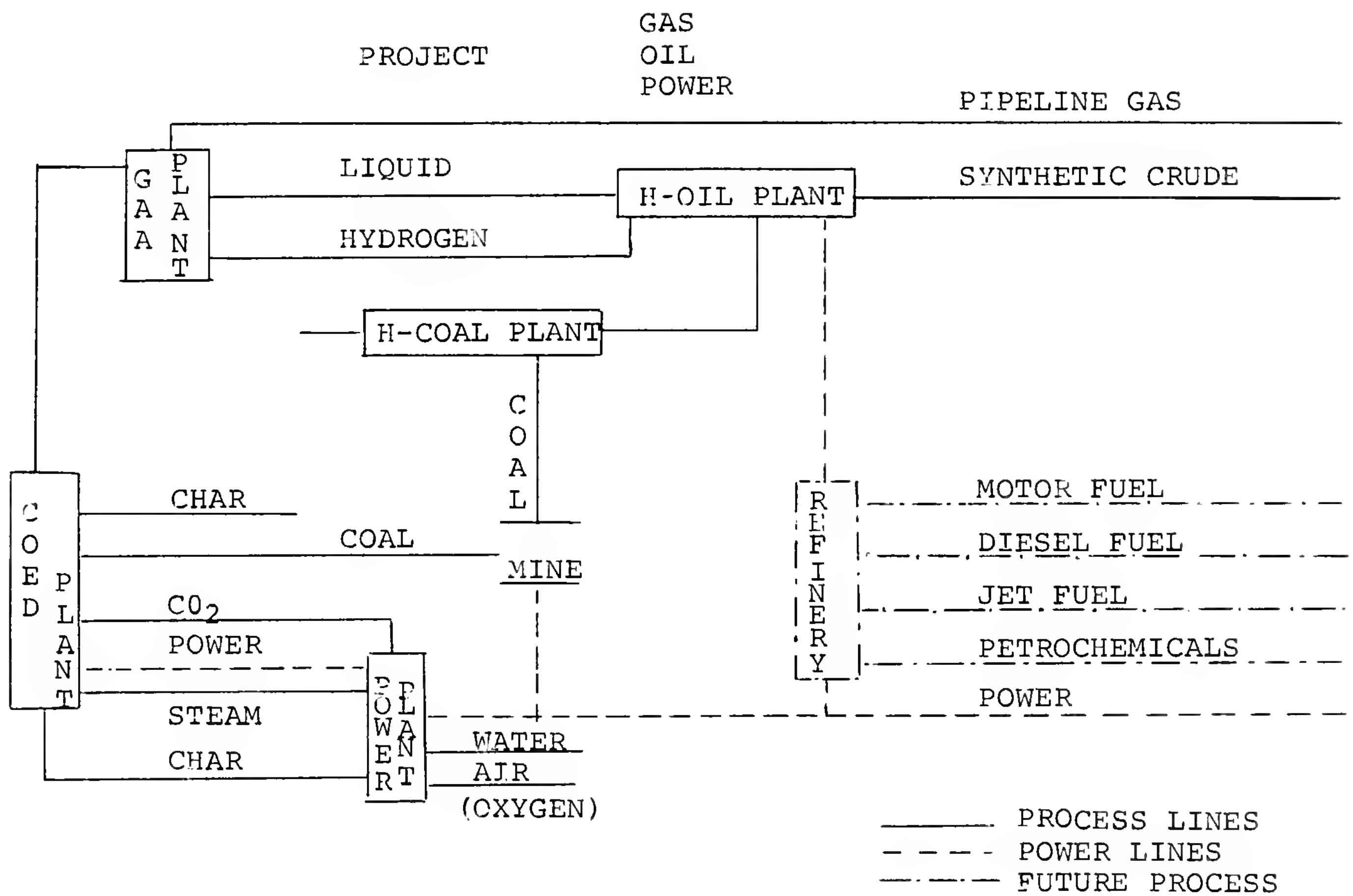
be much greater than that of coal-steam plants, with less atmospheric pollution. Water requirements should be low. Another process called electrogasdynamics has been studied. It is said that the cost of power plants of the EGD process would cost about 20 to 30 percent of equivalent capacity conventional plants and have a much higher efficiency.

Operation of a conventional 500 MW steam generation plant, as referred to in Chapter V, is possible under existing technology and would require 7,200 acre-feet of water per year. Such a plant, constructed within the next ten years, would employ from 35 to 45 individuals--20 to 25 in the generation plant and 15-20 in the mining activity itself.

All spokesmen for planned conversion processes, both in industry and Federal agencies, state that future commercialization will require huge size to be economic. Neal Cochran of the Office of Coal Research visualizes (Cochran, 1969, p. 171) a coal conversion complex which would include an M.H.D. facility. Such a complex would require 50,000 tons of coal per day, producing 102,000 barrels per day of synthetic crude and 125 million cubic feet of synthetic pipeline quality gas each day. The accompanying electric power plant utilizing by-product char would produce 1,750 MW of which 1,250 MW would be available for export. Construction of plants of this size would create satellite industries for the manufacture of plastics, petro chemicals, and refinery products. Mining investment for the coal volume required would approach $50,000,000, and costs of the conversion facilities would approach $350,000,000 (Herrington, 1969, p. 186). A possible facility layout is shown on Figure IV-3.

Water requirements for an optimum sized power generation-coal conversion plant complex are approximately 60,000 acre-feet per year. Of this total, 30,000 acre-feet may be discharged as warm (90° F. water) for use in special irrigation. Irrigation with warm water from nuclear plants in Oregon has provided information verifying that the application of warm irrigation water is associated with many beneficial effects. Such beneficial effects would include a general warming of the soil and its microclimate, making plants less susceptible to frost, particularly in the early spring and late fall. With new generation power being available, however, it would be possible to pump additional cold water for agricultural and other purposes (Groff, 1970, personal communication).

A conversion-power plant as that envisioned would create jobs in mining, manufacturing, and refining. One such complex



Source: Cochran OCR - October, 1969.

FIGURE IV-3 A POSSIBLE MHD FACILITY AND ASSOCIATED PROCESSES.

could create 15,000 new jobs (Cochran, 1970, p. 173) of which about 500 would be directly engaged in mining. The remainder would be professional engineers, administrators, and highly-trained technicians. Income anticipated would, therefore, be high with a large percentage of the personnel on annual salaries.

Environmental Disturbances and Reclamation

Environmental disturbances associated with a conversion-power plant complex would be very minimal, considering recycling and utilization of all of the constituents of lignite. Ash disposal or utilization could be one of the larger environmental problems, but on a mine-mouth complex it could be utilized in a land reclamation project. Proponents of M.H.D. say that M.H.D. would release no pollutants into the atmosphere. In fact, the sulfur and nitrogen oxide recovered in the process can be converted into fertilizers and sold. Higher efficiencies expected from M.H.D. will also alleviate thermal pollution problems. Mined-land reclamation research in Montana has progressed to the point where successful reclamation can be achieved with costs approximately two cents for each ton of coal mined.

CHAPTER V

WATER SUPPLY AND DEVELOPMENT POTENTIAL

WATER SUPPLY AND DEVELOPMENT POTENTIAL

A. SURFACE WATER

Local Streamflow

Streams of local origin have a low and variable yield and are also subject to relatively high peak flows. Consequently the utilization of surface water supplies has primarily been for stockwater, through storage of the flow from small drainage areas, occasional flood irrigation and more reliable irrigation for small areas, where satisfactory storage facilities have been developed.

An inventory of reservoirs, having a storage capacity of 50 or more acre-feet, was prepared by the Montana Water Resources Board in October 1968. The listing shows 19 such active reservoirs in Garfield County, with a total capacity of 4,550 acre-feet. The inventory shows eight active reservoirs, with a total capacity of 2,718 acre-feet in McCone County. There are many more smaller reservoirs in both areas. The U.S. Geological Survey reports on streamflow, mentions 69 upstream reservoirs or ponds in the Sand Creek drainage in Garfield County above the gaging point. A sampling count of recent maps indicates that, on an average basis, there is a stock pond or reservoir for every two square miles.

The problems of low average yield, great variability of yield, and the relatively high peak flows of short duration present serious problems to utilization. The water needs for irrigation and other purposes are far greater than can reasonably be developed from streams originating in the proposed conservancy district area. However, there are opportunities for fuller use in some localities. The scope of this study does not permit any specific project recommendations, however the information and discussion which follow may provide a better understanding of the local water supply and serve as a preliminary guide to further utilization.

The streamflow records of Dry Creek near Van Norman and Redwater River at Circle are reasonably complete for the last 30 years. There are ten years of record for Sand Creek near Jordan. The recorded flow at these gaging points is somewhat affected by upstream storage in stock ponds and depletion for minor irrigation. It would be reasonable to assume that recorded flow will average at least two-thirds of the natural flow. The monthly and

annual flows in acre-feet are given in Tables V-A and V-B for Dry Creek and Redwater River.

Much of the annual runoff occurs in the early snow melt period. In about half the years, rain-caused peaks are responsible for appreciable runoff in June or July. Figure V-1 is a graph of the average monthly runoff of Redwater River at Circle in acre-feet. A dashed horizontal line representing the average of all months is shown for comparison with the monthly averages. From the foregoing tables, the variations within any one month are somewhat apparent The graph of daily flows for Redwater River at Circle, for the water year ending September 30, 1963, is shown as Figure V-2 It is a fairly typical flow pattern, and is presented to show the sharp daily variations.

The relationship between precipitation and runoff varies greatly In general, the spring breakup yields the most runoff, because absorption by the soil or vegetation is low and also evaporation is at a minimum. Rains of an intensity far greater than the corresponding capacity of the soil to absorb water produce high peaks and a substantial runoff volume for brief periods. The average annual precipitation in the Dry Creek and Redwater River basins is about 11.5 inches The records for Dry Creek show an average annual runoff of 0 28 inches or about 2.5 percent of the precipitation Comparable data for Redwater River are 0.37 inches of runoff or 3.2 percent of the precipitation. The shorter period of record for Sand Creek shows a lesser yield. A partial record of runoff has been collected in the Duck Creek and East Fork of Duck Creek basins near Brockway since 1964. Runoff ranging from a minimum of 0.15 inches to as much as 1.03 inches was recorded for each of the several intermittent peak flow periods. The spring breakup flow was not determined in 1964 and 1967. If these records are typical, a square mile of drainage area would, on the average, yield approximately 15 acre-feet of runoff water, during relatively low runoff years.

The ground conditions at the time of snow-melt and the intensity and volume of the rains greatly affect the precipitation-runoff relationship In single periods of snow-melt or heavy rains, runoff as great as 0.64 inches has been recorded in the Duck Creek area This would be equivalent to 34 acre-feet per square mile. The period of record for which volume runoff data are available for small areas is very brief. If we use the long-term record of Redwater River as a guide, it appears that at least 15 acre-feet of water per square mile could be expected in about 7 out of

TABLE V-A
MONTHLY AND ANNUAL RUNOFF, IN ACRE-FEET,
OF DRY CREEK NEAR VAN NORMAN, MONTANA
(DRAINAGE AREA, 2,554 SQUARE MILES)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Annual
1940	0	12	32	0	0	1,430	2,910	642	2,930	556	1,180	0	9,690
1941	19	24	18	3.4	0	400	318	211	5,190	669	911	5,840	13,600
1942	563	104	50	21	28	10,170	340	1,210	9,540	197	104	136	22,460
1943	645	674	3.0	0	23,600	39,870	1,550	397	15,110	841	297	6.9	82,990
1944	86	665	618	14	0	24,710	2,690	567	32,850	2,140	564	67	64,970
1945	138	246	95	0	323	1,320	378	124	688	97	99	5.0	3,510
1946	19	418	444	2,420	13,080	2,350	164	370	880	2,750	25	574	23,490
1947	904	251	91	182	13,190	100,800	3,440	457	716	251	482	109	120,900
1948	-	-	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-	-	-	-	-
1950	13	16	3.0	0	0	3,050	26,880	516	4,830	410	58	101	35,880
1951	146	25	4.8	5.8	715	4,380	940	99	175	53	684	2,300	9,530
1952	140	357	824	10	3,700	16,840	121,600	783	407	129	22	6.5	144,800
1953	27	84	44	4.0	25	3,840	124	14,400	18,490	1,720	2,000	52	40,810
1954	1,890	227	139	9.7	3,580	575	2,960	237	1,680	24	22,560	669	34,550
1955	238	220	112	63	597	6,690	3,850	1,160	1,080	3,880	116	2.2	17,950
1956	22	15	.6	0	0	16,150	352	277	161	731	324	50	18,080
1957	15	44	17	16	854	5,970	390	311	135	5.6	336	88	8,180
1958	15	88	66	0	113	186	127	13	140	892	7	0	1,650
1959	109	63	54	0	0	108,200	2,530	425	544	138	0	228	112,300
1960	172	116	144	14	995	72,920	1,170	477	75	45	1.2	0	76,130
1961	0	0	0	4.4	96	169	62	57	59	0	219	3,390	4,060
1962	97	37	14	103	347	4,450	303	975	2,860	12,140	531	45	21,910
1963	324	81	81	33	14,590	2,830	747	917	3,910	317	12	23	23,860
1964	0	0	0	0	0	178	408	914	17,100	2,950	157	211	21,920
1965	50	42	3.6	0	145	4,550	37,680	5,120	2,210	3,320	999	260	54,380
1966	149	164	148	18	0	5,770	436	289	587	7,070	1,340	123	16,090
1967	65	153	255	74	714	6,380	1,410	4,480	4,350	554	68	1,500	20,000
1968	148	87	24	103	7,960	6,880	529	65	1,320	2,120	362	55	19,650
1969	41	95	107	8.7	8.7	13,380	2,730	1,570	1,060	22,210	e 350	e 60	41,620
Max.	1,890	674	824	2,420	23,600	108,200	121,600	14,400	32,850	22,210	22,560	5,840	144,800
Min.	0	0	0	0	0	169	62	13	59	0	0	0	1,650
Average 1940-47													
1950-69	216	154	121	111	3,024	16,590	7,751	1,324	4,610	2,365	1,207	567	38,030
Median*	92	88	60	9.2	335	5,160	844	467	1,200	612	310	78	22,190

Notes: e - Estimated on basis of Redwater River record.
* - Mid-point; an equal number of items are higher and lower than this quantity.

TABLE V-B

MONTHLY AND ANNUAL RUNOFF, IN ACRE-FEET, OF REDWATER RIVER AT CIRCLE, MONTANA (DRAINAGE AREA, 547 SQUARE MILES)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Annual
1938	9.9	14	6	6	555	10,930	159	38	3,920	5,480	54	35	21,210
1939	22	29	6.1	6.1	0	14,170	70	770	420	0	0	4.0	15,550
1940	14	13	4.2	1.0	1.8	23	98	41	81	12	0.2	0	289
1941	0	0	0	0	0	2.8	6.0	1.8	3.8	0.4	0	12	27
1942	7.1	5.2	1.2	0	0	2,800	61	93	260	6.3	1.0	0.2	3,240
1943	0.2	0.4	0	19	7,850	6,680	259	134	224	30	2.6	0	15,200
1944	1.0	0	0	0	0	15,570	2,950	187	9,960	465	454	63	29,650
1945	46	65	32	14	361	1,190	168	46	40	5.2	9.3	4.4	1,980
1946	14	0	0	0	5,680	422	27	13	6.7	2,570	13	17	8,760
1947	34	24	16	19	6,510	15,920	1,210	154	251	47	142	6.7	24,330
1948	6.1	7.9	12	8.5	447	2,590	165	82	2,690	6,520	1,230	14	13,770
1949	50	6.0	0	0	0	15,740	686	118	41	5.6	0	0	16,650
1950	0	0	0	0	0	1,620	6,600	254	111	18	2.0	16	8,620
1951	15	9.3	8.9	.4	2,820	4,880	479	100	21	5.6	3.4	128	8,470
1952	14	27	528	.2	0	18,370	24,890	122	28	742	7.9	0	44,730
1953	1.8	5.4	6.1	6.1	0	125	24	417	3,420	682	1,600	7.7	6,300
1954	40	22	16	9.3	3,070	113	208	45	46	3.2	715	87	4,370
1955	15	12	13	2.4	4.0	4,940	554	295	109	1,650	139	2.0	7,740
1956	5.0	4.2	2.2	1.6	3.0	6,420	179	83	95	1.0	0	0	6,710
1957	0	3.4	0	0	1,190	6,890	880	171	173	7,150	228	252	16,940
1958	23	31	20	13	8.3	19	55	14	30	26	0	0	216
1959	0	2.2	0	0	0	23,830	470	98	28	3.8	0	0	24,340
1960	.4	.8	2.4	0	.4	20,840	248	431	33	3.4	3.0	0	21,560
1961	0	0	1.8	30	52	11	4.2	1.4	0.2	0	0	0	101
1962	0	0	0	0	0	352	4.2	3.0	2,160	3,620	2.6	3.8	6,170
1963	6.7	6.5	7.7	2.8	6,920	1,320	340	295	6,390	178	8.1	1.4	15,480
1964	0	5.2	4.6	0	2.2	41	53	98	1,640	4,170	26	16	6,060
1965	8.3	11	3.2	4.4	1.4	407	3,740	726	2,110	517	118	30	7,680
1966	32	49	50	8.5	10	1,940	153	74	44	8.9	0	0	2,370
1967	0	0.9	3.4	2.0	230	1,130	520	582	239	14	0	0.5	2,720
1968	1.0	0	0	2.6	150	376	17	6.7	36	11	6.4	0.8	608
1969	1.4	2.0	1.0	1.3	0	2,490	620	479	69	213	18	1.4	3,900
Max.	50	65	528	30	7,850	23,830	24,890	770	9,960	7,150	1,600	252	44,730
Min.	0	0	0	0	0	2.8	4.2	1.4	0.2	0	0	0	27
Ave. 1938-69	11.5	11.1	23.4	4.9	1,121	5,692	1,424	187	1,084	1,067	149	22.0	10,810
Median*	6.4	5.3	3.3	1.8	3.5	2.215	194	99	104	22	4.9	2.9	7,710

*Midpoint; an equal number of items are higher and lower than this quantity.

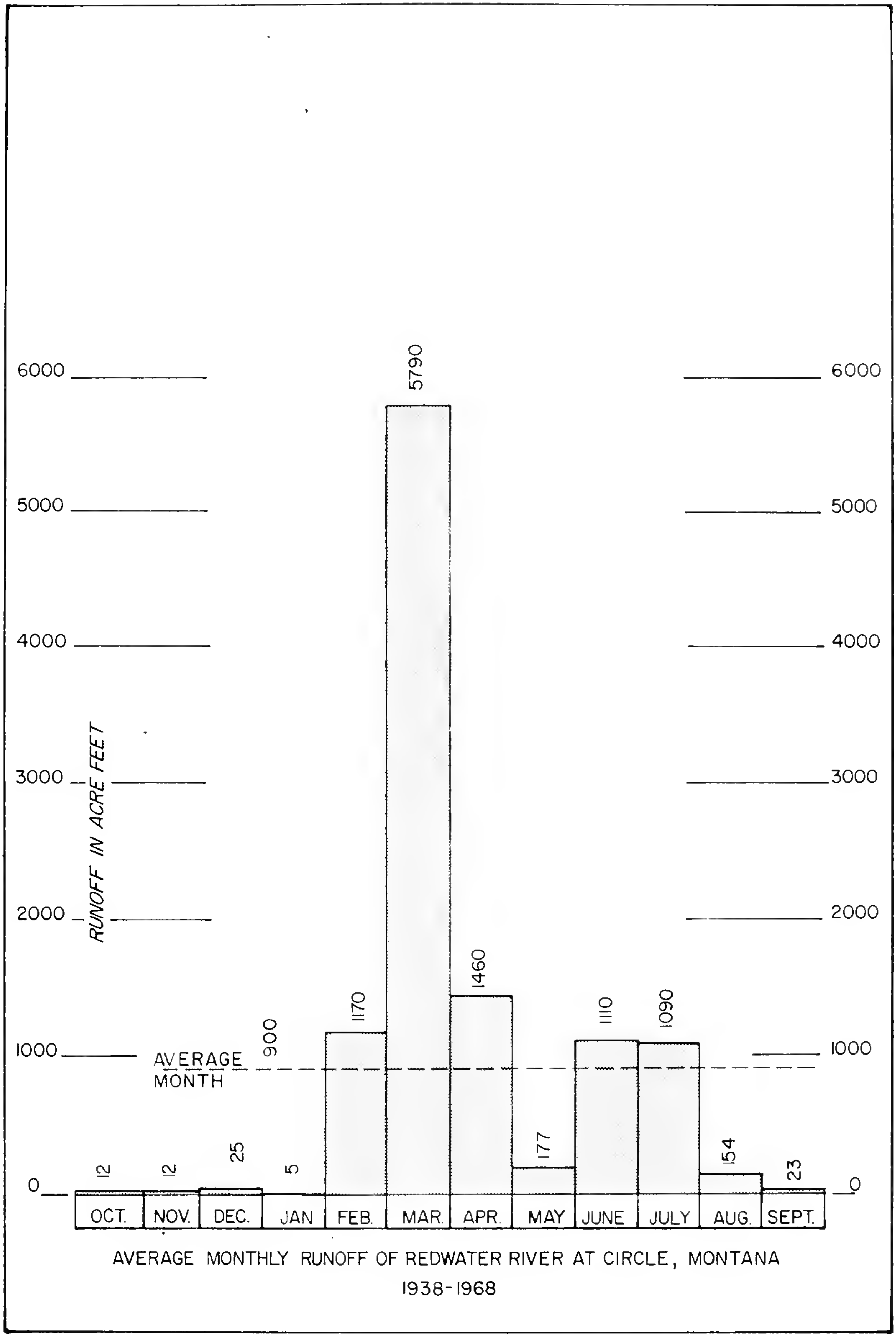
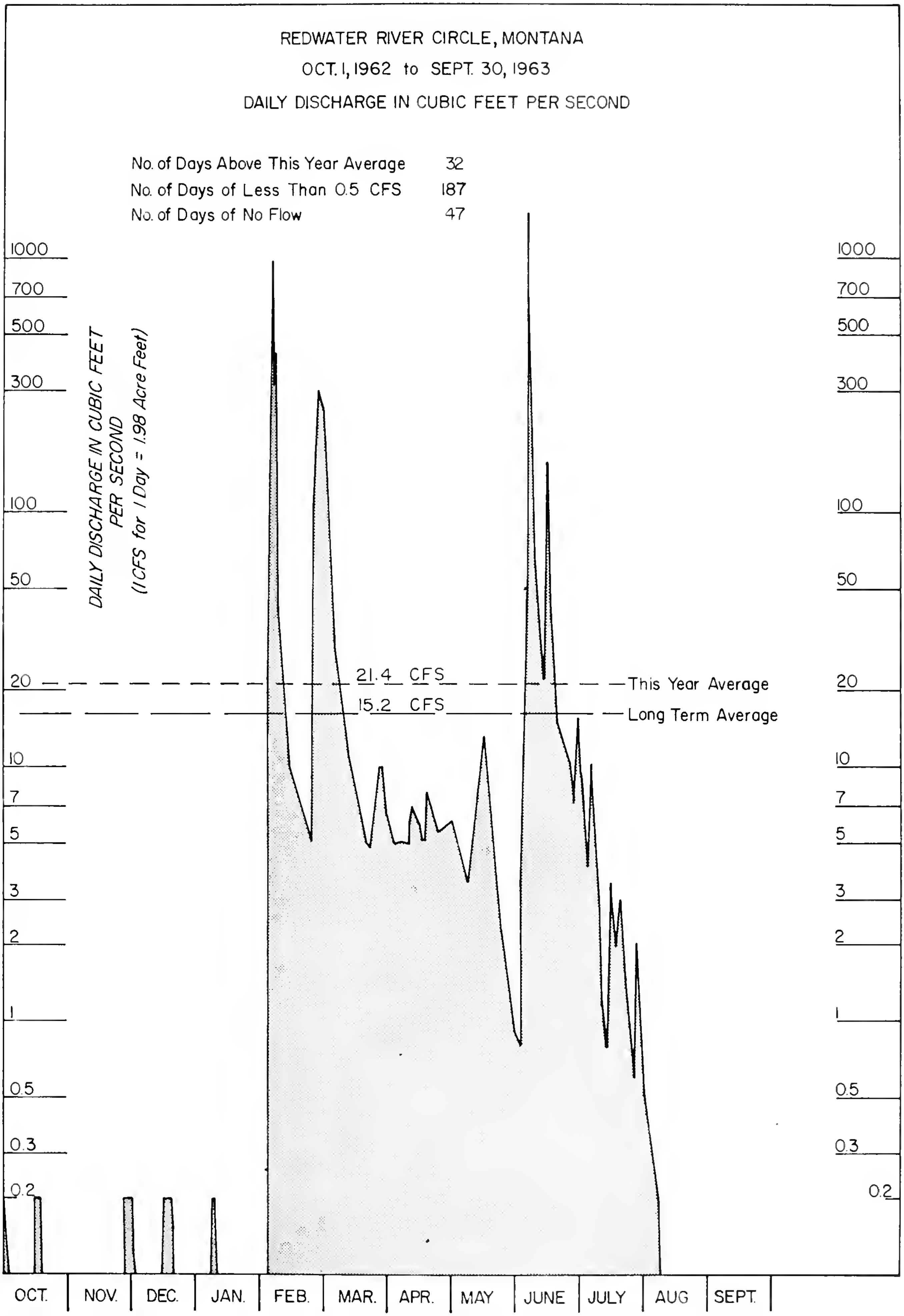

RUNOFF IN ACRE FEET
6000
5000
4000
3000
2000
1000
0
AVERAGE MONTH
900
12
12
25
5
1170
5790
1460
177
1110
1090
154
23
OCT.
NOV.
DEC.
JAN
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
AVERAGE MONTHLY RUNOFF OF REDWATER RIVER AT CIRCLE, MONTANA
1938-1968

Figure V-1

Figure V-2

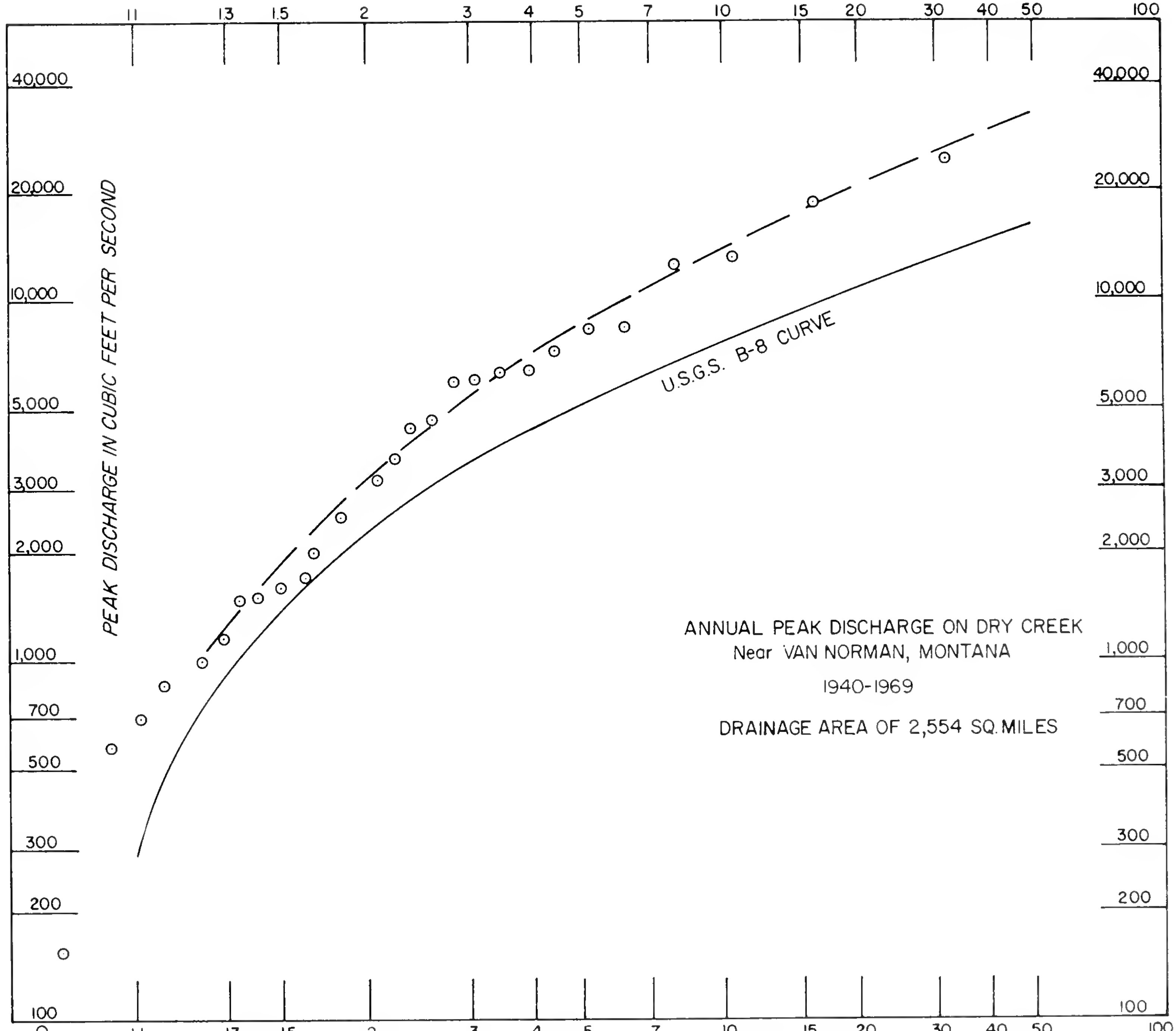

REDWATER RIVER CIRCLE, MONTANA
OCT. 1, 1962 to SEPT. 30, 1963
DAILY DISCHARGE IN CUBIC FEET PER SECOND
No. of Days Above This Year Average 32
No. of Days of Less Than 0.5 CFS 187
No. of Days of No Flow 47
DAILY DISCHARGE IN CUBIC FEET PER SECOND
(1 CFS for 1 Day = 1.98 Acre Feet)
21.4 CFS
This Year Average
15.2 CFS
Long Term Average
1000
700
500
300
100
50
20
10
7
5
3
2
1
0.5
0.3
0.2
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG
SEPT.

10 years. These longer term records also show that drought periods, of practically no runoff, can occur for several years in succession. Rainfall records also show that the intensity and total precipitation can vary greatly even within a few miles, particularly during thunderstorms. Evaporation rates from reservoirs vary with water depth and exposure to sun and wind and other factors. If we deduct the precipitation on the reservoir surface, the net yearly evaporation from shallow reservoirs may generally exceed three feet.

The rate of peak flow and the volume of flow affect the design of reservoir freeboard, spillway capacity and numerous structures, such as diversion dams and irrigation canals. Peak flow information on a number of small drainages in the study area has been collected for 7 to 15 years. Statistical analysis of these records provides some basis for determining the probability or percentage chance of the occurrence of peaks at a frequency of about 25 years. A so-called "25-year flood" has two chances in three of occurring or being exceeded within any 25-year period. This should not be understood to mean that there can be only one 25-year size flood occur in a 25-year period. A 50-year flood has a 40 percent chance and a 100-year flood has a 22 percent chance of occurring in any 25-year period. Graphic analyses of the probable frequency of annual peaks of various magnitude for Dry Creek and Redwater River are shown as Figures V-3 and V-4. The solid lines are based upon regional flood studies by the U.S. Geological Survey. The small circles are the plotting points of recorded peak flows.

An open-file report of the U.S. Geological Survey, issued in 1967, suggests preliminary values of the 10-year and 25-year peak flows of areas from 1 to 100 square miles. The applicable curves for this general area are plotted in Figure V-5 on logarithmic scales. The available experience record for streams in the study area and contiguous areas are also plotted to indicate the spread. The plotting indicates that the intensity of rains over small areas has been greater than would be expected in a typical 25-year period, or that the 25-year curve is significantly low for areas of less than about five square miles. A preliminary curve was drawn, for areas up to ten square miles, to obtain estimates of structures, which would be required to pass local inflow over canals or for diversion dams.

The volume of runoff from a flood peak may have more bearing on desired reservoir spillway size than the instantaneous peak flow. U.S. Weather Bureau Technical



ANNUAL PEAK DISCHARGE ON DRY CREEK
Near VAN NORMAN, MONTANA
1940-1969
DRAINAGE AREA OF 2,554 SQ. MILES
U.S.G.S. B-8 CURVE
PEAK DISCHARGE IN CUBIC FEET PER SECOND
RECCURENCE INTERVAL IN YEARS
100
200
300
500
700
1,000
2,000
3,000
5,000
10,000
20,000
40,000
1.1
1.3
1.5
2
3
4
5
7
10
15
20
30
40
50
100

Figure V-3

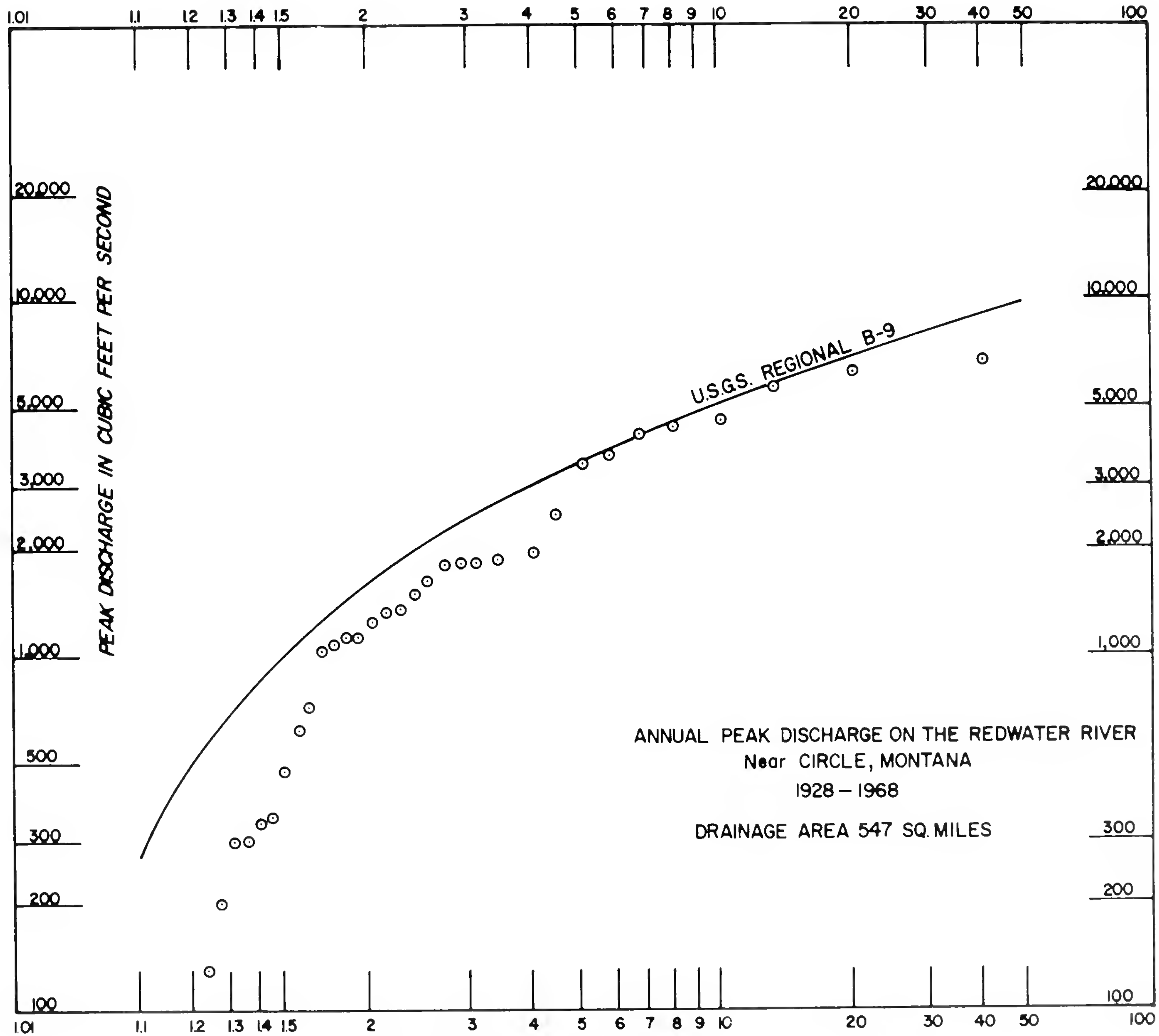
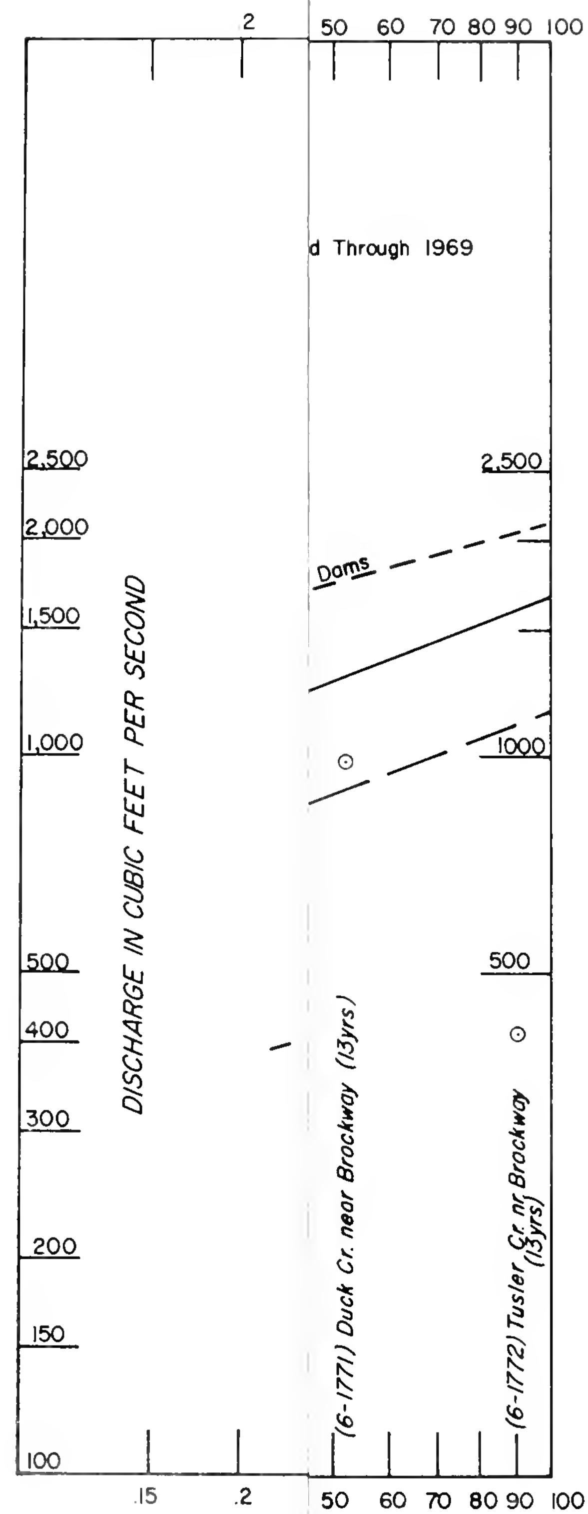

USGS. REGIONAL B-9
ANNUAL PEAK DISCHARGE ON THE REDWATER RIVER
Near CIRCLE, MONTANA
1928 – 1968
DRAINAGE AREA 547 SQ. MILES
PEAK DISCHARGE IN CUBIC FEET PER SECOND
RECURRENCE INTERVAL IN YEARS
1.01
1.1
1.2
1.3
1.4
1.5
2
3
4
5
6
7
8
9
10
20
30
40
50
100
200
300
500
1,000
2,000
3,000
5,000
10,000
20,000

Figure V - 4



2
50 60 70 80 90 100
d Through 1969
2,500
2,000
1,500
1,000
500
400
300
200
150
100
DISCHARGE IN CUBIC FEET PER SECOND
Dams
1000
(6-1771) Duck Cr. near Brockway (13yrs.)
(6-1772) Tusler Cr. nr. Brockway (13yrs.)
.15
.2

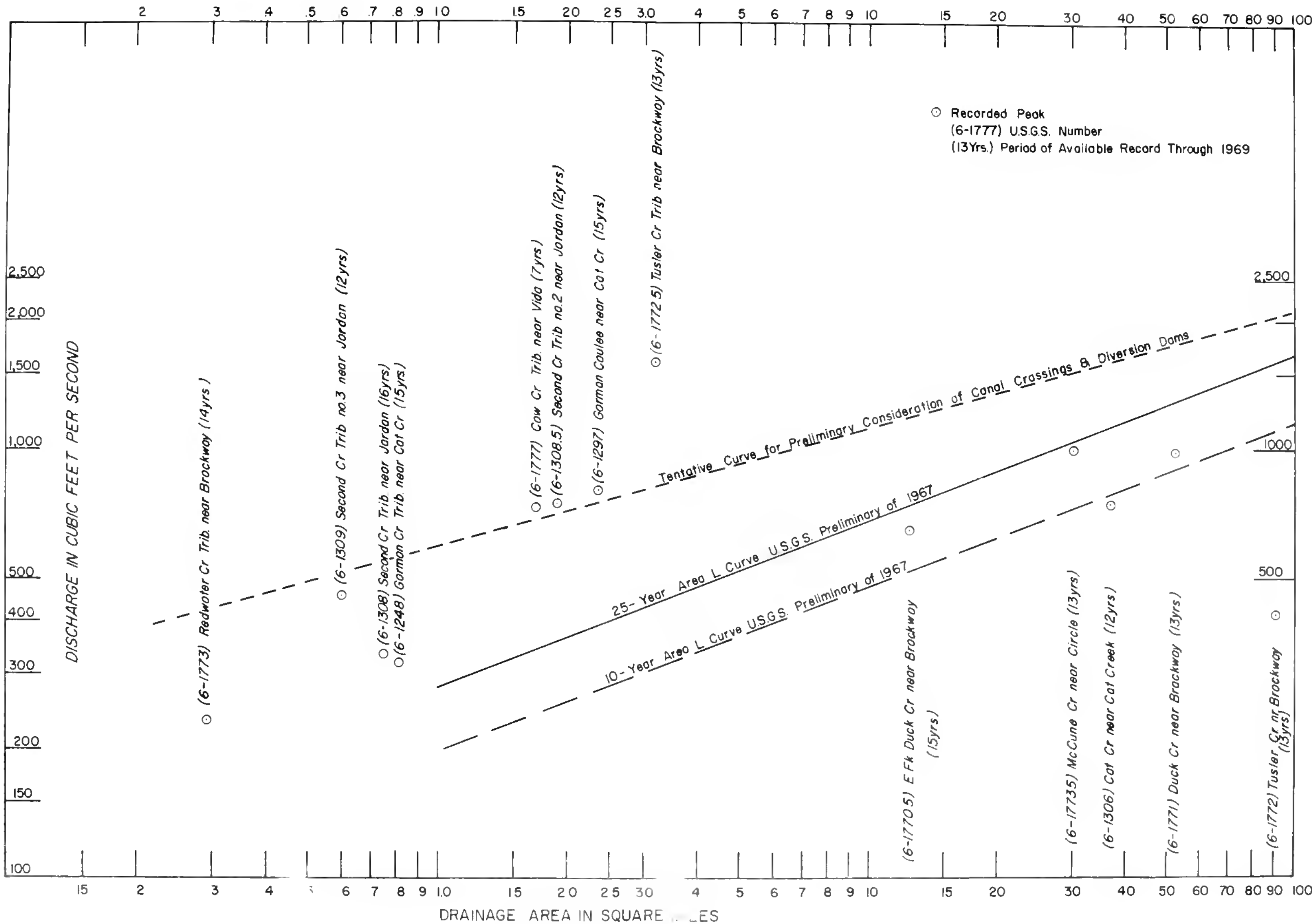


Figure V-5

PEAK DISCHARGE FROM SMALL DRAINAGE AREAS

Papers Nos. 38 and 40 provided the basis for the following calculated data on precipitation and frequency for areas of up to ten square miles in this study area.

Duration of Rain	Maximum Probable	Double 100-yr.*	100-year	50-year	25-year	10-year
24 hours	23"	8.4"	4.2"	3.8"	3.4"	2.9"
6 hours	17"	6.4"	3.2"	2.8"	2.5"	2.1"
1 hour	11"	4.4"	2.2"	1.8"	1.6"	1.3"
1/2 hour	9" (about)	3.5"	1.75"	1.4"	1.25"	1.15"

* Theoretical frequencies in excess of 10,000 years.

In 1921 there was a rainstorm, which was apparently centered at Springbrook, near Circle, that also covered a broad area. The records show 10.5 inches fell in six hours and a total of 15.1 inches in four and one-half days. The statistical data, upon which the above precipitation table is based, would indicate a probable frequency for that type of storm of only one in many thousands of years.

It is beyond the scope of this report to set detailed standards for desirable reservoir freeboard and spillway capacity for the storage of local runoff. The factors of potential damage through structural failure as well as watershed and storm characteristics, require detailed individual study. Experience does indicate that storm frequency greater than the theoretical 100-year storm should generally be used. In preparing highly preliminary estimates of the cost of reservoirs intended for storage of water from Fort Peck Reservoir, a minimum capability for safe release or storage of double the probable 100-year storm has been used. The safety aspect has prompted the tentative selection of dam sites on small natural drainage areas for these storages.

The safe storage of the intermittent and greatly varying streamflow presents some serious problems to the utilization of local runoff for reasonably firm irrigation. The suitability of the dam site for the construction of adequate spillway capability, as well as the desired storage capacity should be considered. These considerations may generally limit safe storage projects to drainage areas of less than ten square miles. The annual runoff from ten square miles may average about 150 acre-feet. However, to be reasonably sure of 150 acre-feet each year, the storage capacity should

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be about double that amount, or 300 acre-feet. The above statements are not intended to imply that some relatively large storage projects in the area would not be feasible. Larger projects may also have distinct non-irrigation benefits, which could ultimately bear a part of the cost under conservancy district procedures.

Musselshell River

The Musselshell River forms the western boundary of Garfield County. It rises in the Little Belt and Castle Mountains west of Harlowton, and has a drainage area of about 5,900 square miles at the southwestern edge of Garfield County. About 103,000 acres upstream from Mosby receive full or flood irrigation from the Musselshell River or tributaries. Nearly one-half of the above irrigation is upstream from Ryegate The Montana Water Resources Board has constructed a number of works for full and supplemental irrigation, with storage reservoirs constructed by that agency having a combined capacity of about 120,000 acre-feet. There are also many other reservoirs for irrigation and stockwater supplies. The extensive upstream use of the runoff in this basin sometimes depletes the summer flow to a trickle

Continuous records have been collected at Mosby since 1932, by the U.S. Geological Survey in cooperation with State and Federal agencies. The average annual runoff for the years 1930-1932 and 1934-1968 was 157,100 acre-feet per year. The lowest annual runoff recorded was 11,840 acre-feet in 1961. Flows of zero to five cubic feet per second (ten acre-feet per day) are not uncommon for brief or extended periods in most years. The peak discharge of record was 18,000 cubic feet per second on June 18, 1944.

A flood frequency study of the U.S. Geological Survey rates the recorded peak as having a recurrence interval of 15 years. No tabulation of past discharge records is given in this report, because of the limited small-scale use that might be made of the stream in the study area. Discharge records are published by the U.S. Geological Survey. Tributaries of the Musselshell River in Garfield County are intermittent streams, with the characteristics of those described in the Local Streamflow discussion. The low infiltration capacity of the Bearpaw Shale, that is exposed in some of these tributaries, would indicate that spillway requirements for storage dams in such drainages should be carefully considered before any sound conclusions or recommendations could be made as to storage on these streams.

Fort Peck Reservoir

Fort Peck Reservoir and the Missouri River below Fort Peck Dam are the only surface water sources in the area that do not have serious limitations of quantity or quality for major water resources development. The drainage area of the Missouri River system at Fort Peck Dam is 57,500 square miles. Although there are upstream diversions for the irrigation of about 880,000 acres, the regulation by upstream reservoirs and particularly Fort Peck Reservoir, is sufficient to smooth out seasonal variations and annual variations to a considerable degree Fort Peck Reservoir performs a flood control function, as well as generation of electric power on-site and regulation for downstream power and navigation.

The capacity of Fort Peck Reservoir is 19,140,000 acre-feet, measured at the top of the spillway gates or at an elevation of 2,250 feet. The sill of the spillway gates is at an elevation of 2,225 feet. The lower limit of on-site power generation is at an elevation of 2,160 feet, at which point the usable storage is 4,535,000 acre-feet. This number excludes the dead storage of 617,000 acre-feet. Under present plans of operation, the reservoir stage is expected to fluctuate between about 2,230 and 2,245 feet elevation in average years. Past records indicate that reservoir elevations of about 2,200 feet may occur after a series of dry years.

The Corps of Engineers, U.S. Army Engineers, constructed and manage the reservoir. That agency's area representative has indicated that the water in the reservoir would be available for irrigation without charge. A charge may, however, be considered appropriate for non-irrigation uses. The interests of all agencies, in the stored waters and lands adjacent to the reservoir, should be clarified in the early stages of definite planning for the diversion from Fort Peck Reservoir.

Missouri River

The annual average flow of the Missouri River below Fort Peck Dam was 9,192 cubic feet per second, or 6,655,000 acre-feet, during the period 1943-1968. During the same period, the annual average flow of the Missouri at Wolf Point was 9,877 cfs, or 7,151,000 acre-feet. The releases at Fort Peck Dam are generally lower when unregulated streams are high Past records indicate that April through June releases are generally in the range of 4,000 to 7,000 cfs. The Milk River enters the Missouri River near Nashua.

The storage at Fresno Reservoir near Havre and the summer diversion of water from the St. Mary River into the Milk River Basin have some regulatory effect. About 140,000 acres of land are irrigated from the Milk River.

Water quality of the Missouri River is good. The total dissolved solids are about 400 parts per million and the calcium carbonate hardness is about 220 ppm. The seasonal variations in chemical quality are small, because of the averaging effect of Fort Peck Resèrvoir. The reservoir also has a very beneficial effect, through deposition of upstream sediments. The Milk River enters the Missouri River below Fort Peck Dam and occasionally contributes sediment that causes turbidity of the larger stream. The irrigation quality of the water is not affected.

B. GROUNDWATER

Quantity

Groundwater of the study area is the primary supply for domestic use and provides stockwater for much of the rangeland. State-wide records of appropriation and related information are available at the offices of the Montana Water Resources Board, Helena, and the Montana Bureau of Mines and Geology, Butte. As of January, 1970, records from the Montana Bureau of Mines and Geology show that there have been 1,029 appropriations filings for wells and 145 filings for springs in Garfield County. The identified purposes of appropriation show 667 wells were for stock use, 206 for stock and domestic use, and 126 wells for domestic use. The expected use of only 73 springs was reported, of which 67 were for stockwater and 6 for both stock and domestic use.

In McCone County, 604 well appropriations and 84 spring appropriations were recorded, as of January, 1970. Identified uses, in McCone County, show 47 wells were for domestic purposes, 164 for domestic and stock, 5 for business, 4 for irrigation and 1 for public water supply. The reports show 56 springs were appropriated for stockwater. No data was obtained for well and spring use in parts of Dawson and Richland Counties, which were considered in this study. However, it can be assumed that the pattern would be quite similar to that in McCone County.

The municipal water supplies of Jordan, Circle and Richey are dependent upon wells, as are the private supplies used in Brockway, Vida and other communities.

The river and stream bottoms have generally yielded larger quantities of water from shallow wells. In the Missouri River bottoms, wells of 100 gallons per minute (gpm) are fairly common and yields of 900 gpm have been developed where underlying gravels are deep. These wells are recharged or fed by the Missouri River or leakage from underlying bedrock. The quality of water often varies with the water level in the river. The Musselshell River bottoms are generally a source of fair to good quality water, which is suitable for livestock and domestic purposes. There is little information available on the yield of wells in other stream valleys. The presence of lenses of sand and gravel would, however, usually result in moderate yields of fair to poor quality water.

Quality

The groundwater is generally of poor chemical quality and contains dissolved solids, well in excess of the standards recommended by the U.S. Public Health Service. Problems of taste, odor, laundry use and culinary use are commonly associated with such water. The chemical analyses of the municipal supplies of Jordan, Circle and Richey are fairly indicative of the groundwater of the study area. These analyses and the standards are given in Table V-C.

The water available from wells and springs in the proposed conservancy district area is generally of low quality, with regard to irrigation. The quality of water for irrigation purposes is usually a function of three variables: (1) the total soluble salt content of the water, (2) the ratio of sodium (Na) to calcium (Ca), plus magnesium (Mg), and (3) the quantity of exotic, but toxic, materials such as boron. There is little evidence of exotic, but toxic, materials in waters of the area, but in general, the soluble salt content and high sodium content of these waters make them unsuitable for irrigation.

High soluble salt waters are unsuitable for irrigation for two reasons. Soluble salts have such a high affinity for water, that plants are unable to extract water from the soil. Thus, the plants suffer from drought, even in relatively wet soils. Also, high soluble salt contents have a direct toxic affect upon plants and, at high levels, will completely prohibit plant growth.

The soluble salt content of water is evaluated by measuring the electrical conductivity of the water. As the salt content increases, the electrical conductivity

TABLE V-C

CHEMICAL ANALYSIS OF MUNICIPAL WATER SUPPLIES
PARTS PER MILLION OR MILLIGRAMS PER LITER

City or Town	a) Std.	Jordan	Circle	Circle	Circle	Circle	Richey	Richey
Source		Well	Well#1	Well#2	Well#3	Comp.	Well#2	Well#3
DAte		8/66	8/67	8/67	8/67	10/66	2/68	2/68
Total Solids	b) 500	2020	2552	2200	2070	2520	1170	1034
Hardness		28	25	115	65	138	45	0
Ca (Calcium)		6	10	18	14	20	8	0
Mg (Magnesium)		3	0	17	7	22	6	0
Na+K (Sodium & Potassium)		740	946	784	746	880	475	345
CO_3 (Carbonate)		18	24	30	42	12	43	55
HCO_3 (Bicarbonate)		522	810	866	866	910	1098	103
SO_4 (Sulfate)	250	1090	1250	940	841	1195	0	0
CI (Chloride)	250	30	22	20	19	23	74	89
NO_3 (Nitrate)		2.1	0	0.2	0	3.5	2.9	2.9
F (Flouride)	1.7	1.1	2.3	2.55	2.6	2.6	4.5	5.0
Fe (Iron)	0.3	0.00	0.2	0.0	0.0	0.14	0.00	0.19
AS (Arsenic)	0.1	0.00	-	0.0	0.0	0.00	0.00	0.00
Pb (Lead)		0.00	-	-	-	0.00	0.00	0.00
Cu (Copper)	1.0	0.00	-	-	-	0.00	0.00	0.00
Zn (Zinc)	5.0	-	-	-	-	-	0.00	0.00

a) Standards of the U.S. Public Health Service for interstate use of water.

b) Total solids up to 1,000 parts per million are acceptable where no better water is available.

increases The electrical conductivity of water is reported as micromhos/cm Water with an electrical conductivity of 750 micomhos/cm is generally satisfactory for irrigation as far as salts are concerned In the conductivity range of from 750-2,250 micromhos/cm, good irrigation practices and salt-tolerant crops must be used. Irrigation with water with a conductivity greater than 2,250 micromhos/cm is almost never successful

The ratio of sodium to calcium plus magnesium in the irrigation water is important, because of the influence of sodium on the physical properties of soils Clays, especially the types of clays found in the soils of the proposed conservancy district, react with sodium, forming soils systems with excessive swelling and shrinking properties Soil systems of this type are almost impermeable to water and air, growth of plant roots and shoots is essentially prohibited, and farming practices such as plowing and irrigation are extremely difficult. The quantity of sodium absorbed on the clay is dependent on the ratio of sodium to calcium plus magnesium in the soil system. This is expressed as the SAR of the system. An irrigation water SAR of greater than about 10 (certainly less than 15) would almost certainly result in destruction of most of the land irrigated.

The table below presents conductivity data (micromhos/cm) and SAR data of water samples submitted to the Soil Testing Laboratory of Montana State University from the proposed conservancy district for analysis. These are random but representative samples, submitted within the last year. Not one of the wells and springs represented by these samples, provides a satisfactory source of irrigation water, because of high salts or high sodium or both.

Conductivity and SAR of Water Samples
from the Proposed Conservancy District

Sample	Conductivity (micromhos/cm)	SAR	Sample	Conductivity (micromhos/cm)	SAR
1	2500	27	6	5000	8
2	3800	7	7	2600	11
3	3400	45	8	2700	10
4	1700	38	9	1800	60
5	4000	10	10	2900	44

Considering the source of sub-surface irrigation water in the area, the low well water quality is not surprising. Nearly all of the sub-surface water is associated, in some way, with shales--often marine shales--that make up an important part of the sub-surface land formation. These shales are generally very high in both soluble salts and sodium. There are, however, exceptions. In some areas there are relatively thick layers of sandstone and in those cases, where water has been accumulated in the sandstone without first moving through the shale, high quality water may exist As is apparent from the above table, these high-quality waters are not common

Much of the shallow aquifer and spring water of the area occurs because of water movement through the upper soil and parent material and collection at some depth on an impermeable shale layer This collected water then moves down a slope and forms a spring at some lower point. These waters are also of low quality because the upper layer of the landscape is also high in salt and sodium. The percolating water collects these materials as it moves.

An important ingredient of many of the waters in the area is sulphate, especially magnesium sulphate. This is also the major ingredient of "milk of magnesia". Thus, the well known and unpleasant effect of these waters on people, especially non-residents of the area, is not surprising.

Geological Formations

The sandstones of many of the formations will yield fair to good quality water, which is suitable for livestock and domestic purposes A discussion of the geology of the area and groundwater information may be helpful in understanding the variations in the yield and quality of water in existing wells and also, aid in further well development. The material that follows, as well as some of the preceding groundwater information, was largely abstracted from discussions of the groundwater of Garfield, McCone and Richland Counties, which were prepared by Mr. Maxwell Botz of the Montana Bureau of Mines and Geology This report was initially prepared for inclusion in a state-wide report on comprehensive water and sewer planning for the Montana Department of Planning and Economic Development.

The geological history of the study area includes long periods of sedimentation, then erosion, regional uplifting

and downwarping of the earth's crust, and continental glaciation. Except for intrusive igneous rocks at Smoky Butte, located eight miles due west of Jordan, all of the exposed rocks are of sedimentary origin and range in age from Cretaceous (65 to 135 million years old) to Recent (less than 20 thousand years old). During most of Cretaceous time, thick sequences of marine sediments were deposited, followed by deposition of a thick carbonaceous sequence, during Late Cretaceous and Early Tertiary time (50 to 70 million years old). Downwarping of the earth's crust caused a regional valley-like structure in the sediments known as the Blood Creek syncline. This structure trends east to west, through central Garfield County, and plunges gently downward to the east. In southwestern Garfield County, the sediments have been further disturbed by the uplifting of the Freedom Dome (15 miles south of Jordan), the Alice Dome (about 15 miles south of Sand Springs), the Mosby Dome at Mosby, and the Porcupine Dome just south of Garfield County.

The Smoky Butte intrusives, a local feature , are igneous rocks that forced their way upward through the sediments into the lower member of the Fort Union Formation. These intrusive rocks are located about eight miles due west of Jordan and are not extensive enough to be of significance to the water resources of Garfield County.

Rapid uplift and erosion of the Rocky Mountains, to the west, deposited sand and gravel in streams (the Flaxville and Wiota Gravels) in parts of McCone County, during Late Tertiary time (1 to 50 million years ago). Only scattered remnants of these high level terrace deposits remain today. During the Pleistocene epoch (20 thousand to 1 million years ago), the northern half of McCone County was covered by large ice sheets. The ice sheets blocked the Missouri and the Musselshell Rivers' tributaries, creating numerous glacial lakes. One of these, Lake Jordan, covered a large portion of the western half of Garfield County and another, Lake Musselshell, covered much of the western portion of the county. Sediment in these lakes deposited and formed a mantle of silt and clay that covers all but the central third of Garfield County. These lake deposits are not an important source of water, because the sediments are generally too fine to transmit water in usable quantities. Continental ice sheets which advanced a few miles into Garfield County from the north, and in the northern half of McCone County, left a heterogeneous mixture of rocks, boulders, gravels, silts, and clays. Where there are zones of saturated gravels, water of fair to poor quality can be

found in sufficient quantities for livestock and domestic use. Outwash and buried channel deposits (located mostly in the northern half of McCone County) yield small to moderate quantities of highly mineralized water (2 to 20 gpm), provided that they are saturated. Scattered remnants of high level terraces of Early Pleistocene and Late Tertiary age are present along the margins of the Missouri River valley and in the southern part of the county. These older terraces are generally quite thin and extensively dissected by erosion, thus, the terrace deposits contain little or no groundwater.

The sequence and grouping of geologic formations is shown, in a general way, in Table V-D. In the eastern part of the study area, the distinguishing characteristics of many of the formations of the Montana Group, are not clearly evident. The eastward continuation is, then, regrouped as Pierre (Table V-D).

Geologic formations of importance to the groundwater resources are: (1) alluvium of Recent geological age (less than 20 thousand years old), (2) glacial deposits of Pleistocene geologic age (20 thousand to 1 million years old), (3) the Fort Union Formation of Tertiary geologic age (1 to 70 million years old), and the Hell Creek Formation, Fox Hills Formation and Judith River Formation of Cretaceous age (70 to 135 million years old). The underlying formations are of little significance to the water resources, because of their great depth and uncertain quality of the water. Geologic formations, which are important to the water resources are described below, beginning with the most recent strata.

Alluvium of Recent age is present in valley bottoms of the Musselshell River and other major streams in Garfield County. The Musselshell forms the western boundary of that county. Alluvium along the Musselshell consists of clay, silt, sand and gravel mixtures, ranging from 20 to 55 feet in thickness. Wells drilled into this alluvium will generally yield sufficient quantities of fair to good quality water for domestic and livetock purposes. Alluvium in the bottom of the other streams in Garfield County consists of about 5 to 30 feet of silt and clay. Locally, this alluvium may contain lenses of sand and gravel. Wells drilled into this stream alluvium will usually produce small quantities of fair to poor quality water.

Extensive deposits of coarse to fine-grained unconsolidated alluvial material, of Recent age, underlie the

TABLE V-D
SEQUENCE AND GROUPING OF GEOLOGIC FORMATIONS*

Age	Group	Formation	Member
Quantenary		Alluvium Glacial Moraines	
Tertiary		Flaxville Gravel Fort Union	Tongue River Lebo Tullock
Upper Cretaceous	Lance	Hell Creek	
	Montana	Fox Hills	Colgate (unnamed)
		Bearpaw	Pierre
		Judith River	
		Claggett	
		Eagle	
		Telegraph Creek	
	Colorado	Niobrara - carlile	
		Frontier	
		Mowry	
		Thermopolis	

*Source: Stratigraphic Correlation Chart, Billings Geologic Society, 1962.

Missouri River bottom land. In some areas this deposit attains a width of four miles, but in the flood plains of the minor streams of McCone County, it is somewhat narrower. A detailed investigation of the alluvial deposits along the Missouri River, by Hopkins and Tilstra (1966), has shown that the flood plain deposits are up to 150 feet thick and contain mostly clay and silt in the upper part; sandy clay, sand and gravelly sand in the middle part; and sand and gravel in the lower part. In general, the thickest layers of gravel occupy the deeper parts of the valley. Where this basal gravel unit is over 15 feet thick, chances of wells yielding more than 900 gallons per minute (gpm) are good. Yields exceeding 100 gpm can be expected from most wells located in the alluvial flood plain deposits. The alluvium is recharged by leakage from underlying bedrock formations and from the river during the flood season.

Water derived from the alluvium ranges widely in total dissolved solids (TDS) and is commonly characterizied by a predominance of sodium, sulfate and bicarbonate ions. To avoid extensive salt accumulation, this type of water should only be applied to well-drained soils. High concentrations of iron, manganese, sulfate and TDS in the groundwater adversely affect its suitability for domestic supplies; however, residents along the Missouri River have used this water for many years and have become accustomed to its high mineral content.

Detailed information concerning thickness and composition of the alluvium along the smaller streams (Redwater, Timber, Prairie Elk and Sand Creeks) of McCone County is not available. In most cases, the alluvial fill is probably 5 to 40 feet thick and contains mostly stratified clay, silt and sand, with a few gravel lenses. If shallow wells encounter several feet of saturated sand or gravel, small to moderate quantities of water (one to ten gpm) can be expected. Because all the area streams are intermittent, most of the water contained in the alluvium is drained, evaporated from the surface or transpired by the vegetation growing along the creeks; consequently, many wells go dry each summer. Water derived from the shallow alluvium is usually highly mineralized (high in sodium, sulfate and bicarbonate) and is easily polluted.

The youngest consolidated bedrock formation exposed in the study area is the Fort Union Formation of Tertiary age. This formation is composed of three members: (1) Tongue River (youngest), (2) Lebo, and (3) Tullock (oldest).

The downward continuing order of lower sedimentary deposits is the Hell Creek Formation, Fox Hills Formation, Bearpaw Shale, Judith River Formation, Claggett Formation and the Eagle Formation (Table V-D). The remaining discussion of water occurrence in these formations will be on a county basis beginning with Garfield County.

The Fort Union Formation of Tertiary age underlies the glacial lake sediments in eastern Garfield County and is exposed, at the ground surface, in the central part of the county. The formation consists of 1,200 to 1,400 feet of clay, shale, lignite and discontinuous sandstone beds. In the southeast part of the county, a massive sandstone forms the base of the Tongue River Member. This basal sandstone will generally yield sufficient quantities of fair to good quality water to wells for domestic and livestock use. Other sandstones in both the Tongue River and Tullock Member will generally yield adequate amounts of fair to good quality water for livestock and domestic use, although locally the water may be highly mineralized. The Lebo Member consists almost entirely of shale and will yield little or no potable water.

The Hell Creek Formation of Cretaceous age underlies lake silts in part of western Garfield County and underlies the Fort Union Formation elsewhere. The Hell Creek consists of 250 to 400 feet of continental and brackish water deposits of sandstone, shale, mudstone and siltstone. The sandstone beds generally yield soft water to wells in sufficient quantities for livestock and domestic use. Many privately owned wells in Jordan are drilled into sandstone of the Hell Creek and flow at a rate of two to five gallons per minute (gpm) from about 200 feet.

The Fox Hills Formation of Cretaceous age underlies the Hell Creek Formation, although a thin strip of Fox Hills underlies lake silts in extreme western Garfield County. The Fox Hills consists of two members, the 50 to 80 feet thick Colgate Sandstone and a lower, unnamed member consisting of 60 to 100 feet of interlayered sandstone and shale. In part of extreme southern Garfield County, the Colgate Sandstone may have been eroded away before the Hell Creek Formation was deposited. Most wells drilled into the Fox Hills Formation penetrate only the Colgate Sandstone, which generally supplies sufficient quantities of soft water to wells for domestic and livestock use. Usually a basal sandstone in the Hell Creek rests on the Colgate Sandstone, and together, they form a relatively thick and continuous aquifer (water bearing zone).

The Bearpaw Shale is exposed, at the ground surface, on the Mosby Dome, at Mosby, and underlies the Hell Creek Formation. The Bearpaw consists of 900 to 1,100 feet of dark, dense shale that contains virtually no potable water.

Also exposed on the Mosby Dome and underlying the Bearpaw Shale, is the Judith River Formation of Cretaceous age. The Judith River consists of about 500 feet of alternating beds of sandstone and siltstone with some layers of shale and lignite. The sandstone will yield sufficient water to wells for domestic and livestock purposes, but the water quality ranges from fair to highly mineralized. Flowing wells can be obtained along the Missouri and Musselshell Rivers, where the depth to the Judith River is 500 to 1,000 feet.

About 500 feet of dense, dark shale, similar to that of the Bear paw, lies below the Judith River Formation. This formation is the Claggett Formation and is generally nonwater bearing.

The Eagle Formation, which is exposed on the Mosby Dome, underlies the Claggett and consists of 150 to 250 feet of silty and clayey sandstones. The Colorado Group of formations is unsuitable as a source of potable water.

The groundwater resources of Garfield County will likely continue to be developed for livestock and domestic use and, to a minor extent, for municipal and irrigation use. It appears that the Fox Hills and Hell Creek Formations may yield enough water for very small irrigation projects in extreme northwestern Garfield County, near the Missouri River. Extensive and detailed hydrogeological study must be conducted to obtain adequate amounts of water suitable for various purposes.

The Tongue River Member, exposed in the southeastern half of McCone County, attains a maximum thickness of about 700 feet and contains light yellow to gray alternating shales and sandstones, with several persistent coal beds. Because the sandstone units vary considerably in thickness, permeability (ability to yield water), and areal extent, it is difficult to predict well yields and depths. In general, wells of from 100 to 300 feet in depth will encounter enough sandstone lenses and coal beds to yield 2 to 30 gpm. The Tongue River is primarily recharged by precipitation moving through the soil into the groundwater reservoir. The water supplies for the community of Brockway and the majority of the water used by the town of Circle

are derived from the Tongue River Member. The water is moderately to highly mineralized, with sodium, sulfate and bicarbonate being the predominate constituents.

Underlying the southeastern two-thirds of McCone County and dipping beneath the Tongue River, is the Lebo Shale Member of the Fort Union Formation. Where the Lebo has not been exposed to erosion, it is approximately 400 feet thick and is predominantly gray to black shale with scattered lenses of brownish sandstone. Except for the "Big Dirty" coal bed at its base, the Lebo contains only a few lenses of coal, all of which are in the basal 100 feet. The Lebo is virtually impermeable and yields little or no water to wells. If any water is obtained, it is likely to be highly mineralized and is unsuitable for domestic or livestock purposes.

Underlying the Lebo and the southeastern three-fourths of McCone County, is the Tullock Member of the Fort Union. The Tullock is composed of about 165 feet of alternating beds of tan to gray shale, sandy shale and sandstone. The dark shale is commonly carbonaceous, containing thin beds of coal 5 to 30 feet apart. The sandstone lenses and coal beds yield small quantities (two to eight gpm) of poor quality water to wells. Because the underlying Hell Creek and Fox Hills Formations are better aquifers than the Tullock (both in quantity and quality), many wells pass through the Tullock and utilize the deeper aquifers. Some wells in the vicinity of Vida obtain water from the Tullock.

Exposed in the northern part of McCone County and dipping beneath the Fort Union, is the Hell Creek Formation of Upper Cretaceous age. The Hell Creek is reported to be 220 to 280 feet thick, containing mostly dark gray shales with a persistent coal bed at the top and several thick medium-grained crossbedded sandstone units near the base. Wells tapping these sandstone units commonly yield 10 to 20 gpm. Water from the Hell Creek is only moderately mineralized in the northern part of the county, but it becomes highly mineralized to the south, where the formation is deeply buried.

The Fox Hills Formation, exposed along the Missouri River Breaks, underlies the Hell Creek. The Fox Hills is roughly 120 feet thick and contains two prominent members: (1) an upper unit commonly called the Colgate Sandstone, which is about 80 feet thick and is predominantly fine to medium grained, light brown sandstone; and (2) a lower member composed chiefly of thin-bedded, grayish yellow,

sandy shale. The Colgate varies considerably in thickness and may be absent in some localized areas. If the Colgate Sandstone is present, yields of 15 to 40 gpm can be expected from wells. The water is somewhat mineralized, but generally suitable for domestic purposes. The Fox Hills is recharged by precipitation and possibly by the Missouri River in the northeastern part of the county.

The oldest bedrock formation exposed in McCone County is the Bearpaw Shale, containing 1,100 feet of essentially nonwater bearing, dark gray, dense, marine shale.

Underlying the Bearpaw is the Judith River Formation of Upper Cretaceous age. The Judith River Formation contains 300 to 500 feet of grayish white sandstone and light to dark gray sandy shale and shale. A few thin beds of coal and carbonaceous shale are locally present. Individual beds of sandstone or shale are not continuous, either in thickness or composition, and consequently the sequences of rock types differ from place to place. Water obtained from wells drilled into the Judith River is under considerable artesian pressure, and flowing wells are common. Most flowing wells discharge 1 to 15 gpm. Water derived from the Judith River Formation in northwestern McCone County is likely to be highly mineralized (2,500 to 3,500 gpm TDS), with sodium, bicarbonate and chloride being the predominant ions. As the formation becomes more deeply buried to the southeast, the water becomes more mineralized.

Little is known about the groundwater potential of deeper aquifers in McCone County; however, any water obtained from these aquifers is probably highly mineralized and unfit for domestic and livestock purposes.

In summary, there has been little development of groundwater contained in the bedrock formations underlying McCone County. These aquifers are capable of supplying small to moderate quantities of water to hundreds of additional wells, which will likely be drilled in the future. Recent flood plain alluvium along the Missouri River is the only aquifer in McCone County capable of producing large quantities of water for irrigation, industrial and municipal purposes; however, the quality of the water will continue to be a problem. Additional detailed hydrogeological investigations are needed to evaluate the groundwater potential of McCone County.

The geology and groundwater situation of the small parts of Dawson and Richland Counties, involved in this report, are quite similar to those of adjacent parts of McCone County.

With the exception of an area around Lambert, much of Richland County was mantled by glacial deposits. The remaining glacial outwash channels are generally a fair to good source of groundwater. Near Lambert lake sediments of silt, clay and fine-grained sand were deposited as glacial streams were dammed. The Recent alluvium near the Missouri River will yield moderate to large quantities of water as the thickness of underlying gravels vary. The Fox Hills Sandstone is exposed along the Missouri River in the northwestern part of Richland County. Few wells have been drilled into the Fox Hills, but the formation is probably a fair aquifer.

For further detail on these areas and Garfield and McCone Counties, reference should be made to the groundwater discussions prepared by M.K. Botz of the Montana Bureau of Mines and Geology. The discussions will soon appear in the comprehensive water and sewer reports for the separate counties, under contract with the Montana Department of Planning and Economic Development, Helena. These publications also cite other pertinent references.

C. RELATED WATER DEVELOPMENT STUDIES

Musselshell River

The U.S. Bureau of Reclamation investigated an irrigation project, which would provide full-service irrigation to 8,330 acres of land lying adjacent to the Musselshell River in the vicinity of Mosby. Pumping from the Musselshell River, by individual operators, now furnishes intermittent irrigation to 2,110 acres of the project areas. Less than half of the project area lies in Garfield County. Project studies were described in November, 1967 in a Lower Musselshell Unit report prepared by the Upper Missouri Projects Office, Region 6, U.S. Bureau of Reclamation. The report is available for inspection at the offices of the Montana Water Resources Board, Helena. The cost-benefit ratio, resulting from a detailed study of the project, was considered to be unfavorable under the prevailing economic conditions. A brief description of the project follows. The maps of present irrigated land, as found in Section III of the Detailed Map Assembly, together with the potentially

irrigable areas, as fully described in Chapter III of this report, serve, in part, to identify the project area.

Storage is required to firm up the water supply for the present irrigated land and to provide water for the additional lands. After study of reservoir sites and associated spillway requirements, an earth dam 129 feet high, impounding about 70,000 acre-feet, was planned on Flatwillow Creek, about two miles upstream from the Musselshell River. The planned dead storage of 23,000 acre-feet would provide recreational potential and also provide sufficient water release to maintain a downstream fishery. Irrigators would draw their supply, by individually-owned and operated pumping plants, to serve the scattered bottom land along the Musselshell River. A diversion of 2.85 acre-feet per acre was considered adequate for irrigation needs and leaching requirements of the soils. The project construction included drainage of the irrigated areas. The total construction cost was estimated at $12,172,000 on the basis of 1966 price levels. The earth fill dam and reservoir were estimated at $11,668,000, of which $6,088,000 was for the spillway. Excluding the retirement of construction cost, an annual charge of $1.00 per acre was assigned for operation and maintenance of project facilities. It was estimated that the annual operation and maintenance cost of the private facilities would be about $5.00 per acre. The high cost of providing storage facilities for a firm water supply was the factor which made the project infeasible. The large contribution to overall costs, by spillway construction, was undoubtedly a key factor leading to the negative recommendations on feasibility.

Missouri River

The U.S. Bureau of Reclamation conducted a reconnaissance study of a number of small irrigation systems, designed to serve the bottom lands along the Missouri River in Montana, downstream from Fort Peck Dam. It was planned that lands would be served by pumping from the Missouri River. The study is presented in greater detail in a report on "*Northeast Montana Division, Missouri River Basin Project*", prepared by that agency's Upper Missouri Projects Office in Region 6. The report is available at the offices of the Montana Water Resources Board, Helena. Information on those irrigation units, within the boundaries of the proposed conservancy district, was obtained from that report. The proposed units are shown on maps, which were reproduced from

the U.S. Bureau of Reclamation report. The individual project maps follow the text of this sub-section (Figures V-6 through V-9 inclusive).

The Farmer Creek unit (Figure V-6) is situated on a recent alluvial terrace south of the Missouri River near Lost Creek, about 15 miles downstream from Fort Peck Dam. The soils are commonly clay and the undulating surface relief would require some land levelling for efficient irrigation farming. Irrigable lands total 840 acres.

The Wapiti Unit (Figure V-7) contains 3,540 acres of irrigable land. A small part of the proposed unit, lying west of Prairie Elk Creek, is bottom land, ranging from permeable clays to loamy sand and is considered well suited to irrigation. The easterly part, to be served by the Wapiti Canal contain soils ranging in texture from sands to clays. Levelling and drainage are recommended for some of this area. The proposed east canal would extend about two and one-half miles east of Sand Creek.

The Fort Charles Unit (Figure V-8) lies in the river bottom just west of the bridge over the Missouri River on State Highway 13, opposite Wolf Point. Some land levelling and pumping irrigation has taken place. Clay soils of somewhat restricted permeability, in the upper few feet, are fairly common in this 3,060 acre unit. In contrast, some soils near the Missouri River are coarse and rapidly permeable. No salinity problem is expected, because of coarse textures and well structured subsoils. The 35 percent of the area now irrigated by pumping from the river or wells would receive better water service.

The Nickwall Unit (Figure V-9) lies on a recent alluvial terrace located west of the Redwater River and is reported to comprise 2,190 acres. About six percent of the land is currently irrigated and about 60 percent is dryland. The permeable clays, over much of the area, appear to permit good vertical water movement. The coarser soils, adjacent to the river, would require good irrigation management to obtain optimum yields.

Each of the proposed units would have a pumping station and in some cases, relift pumping for parts of a unit. The static lifts would be in the 20 to 30 feet range, except for a 73-foot lift to the Wapiti Canal. About ten percent of the gravity canals and laterals would be lined. All of the systems would also serve present irrigated land, if considered suitable for sustained irrigation. The average

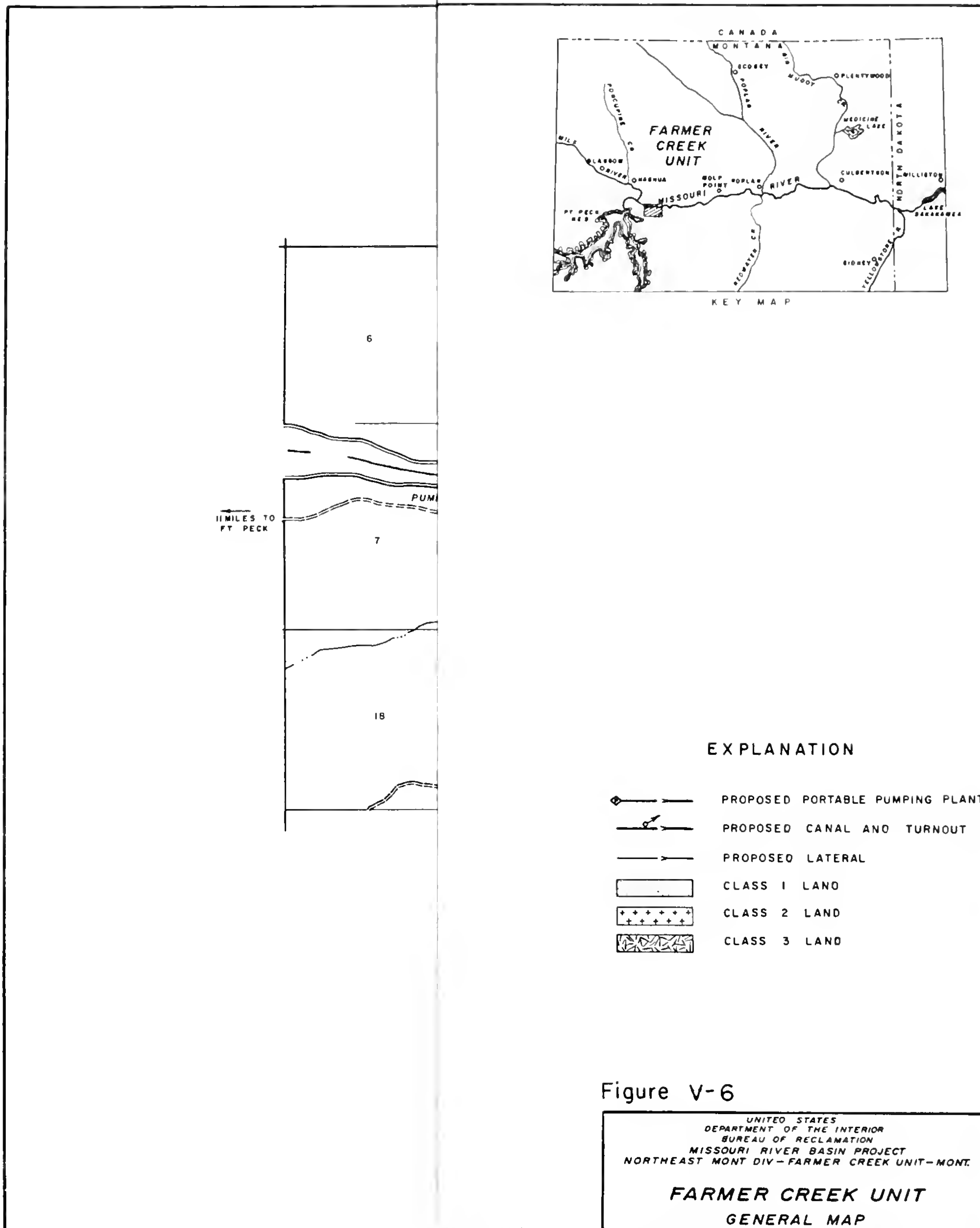


Figure V-6

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV – FARMER CREEK UNIT – MONT.

FARMER CREEK UNIT
GENERAL MAP

DRAWN H.R.D.–H.R.R. SUBMITTED U.W. Stone
TRACED V.P.L. RECOMMENDED G. R. [illegible]
CHECKED U.W.S. APPROVED M. [illegible] PROJECT MANAGER
GREAT FALLS, MONTANA MAR 1967 679–604–35

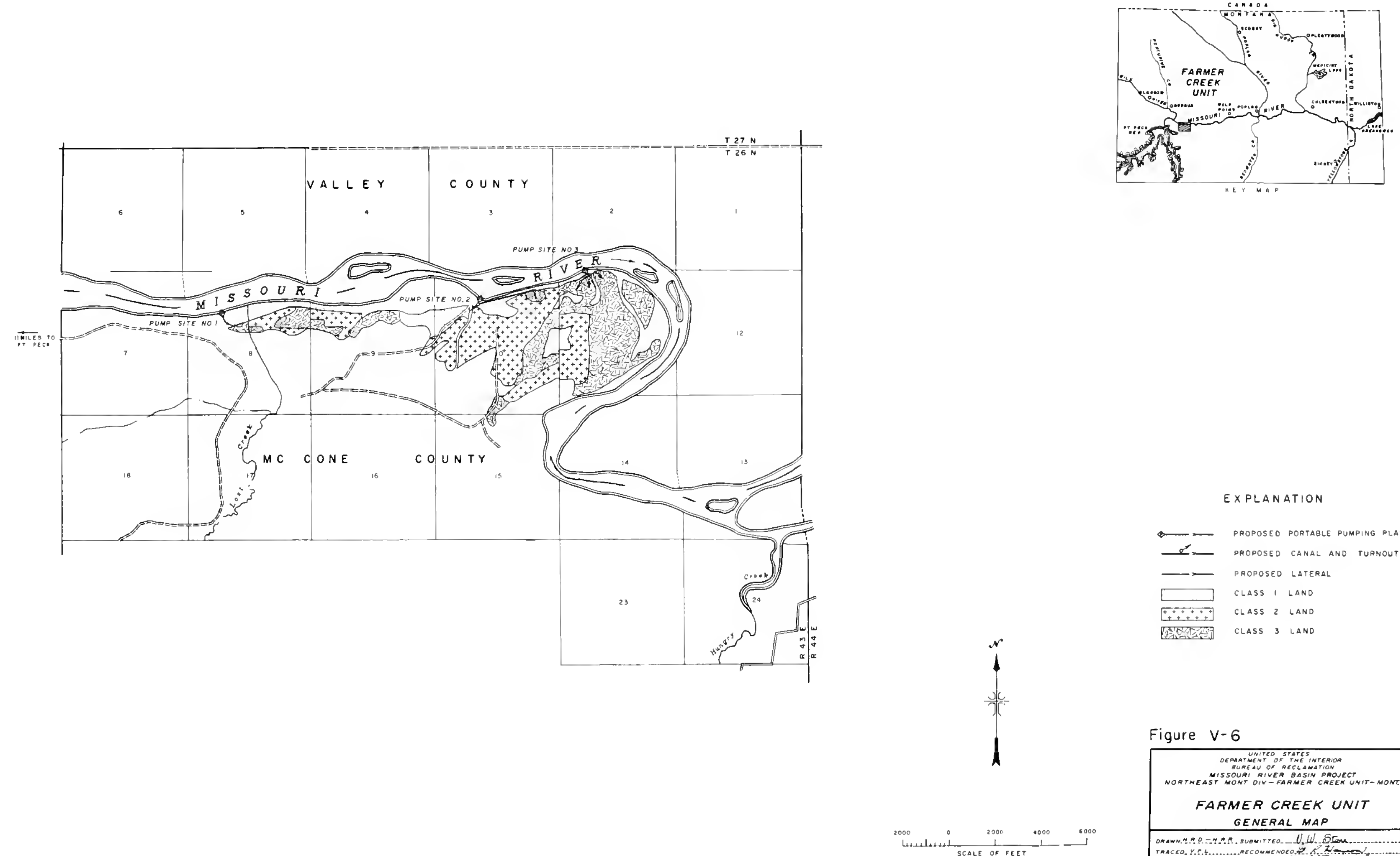


Figure V-6

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV – FARMER CREEK UNIT – MONT.

FARMER CREEK UNIT
GENERAL MAP

DRAWN M.R.D. – M.R.R. SUBMITTED U.W. Stow
TRACED V.P.L. RECOMMENDED
CHECKED U.W.S. APPROVED
PROJECT ENGINEER

GREAT FALLS, MONTANA MAR 1967 679-604-35

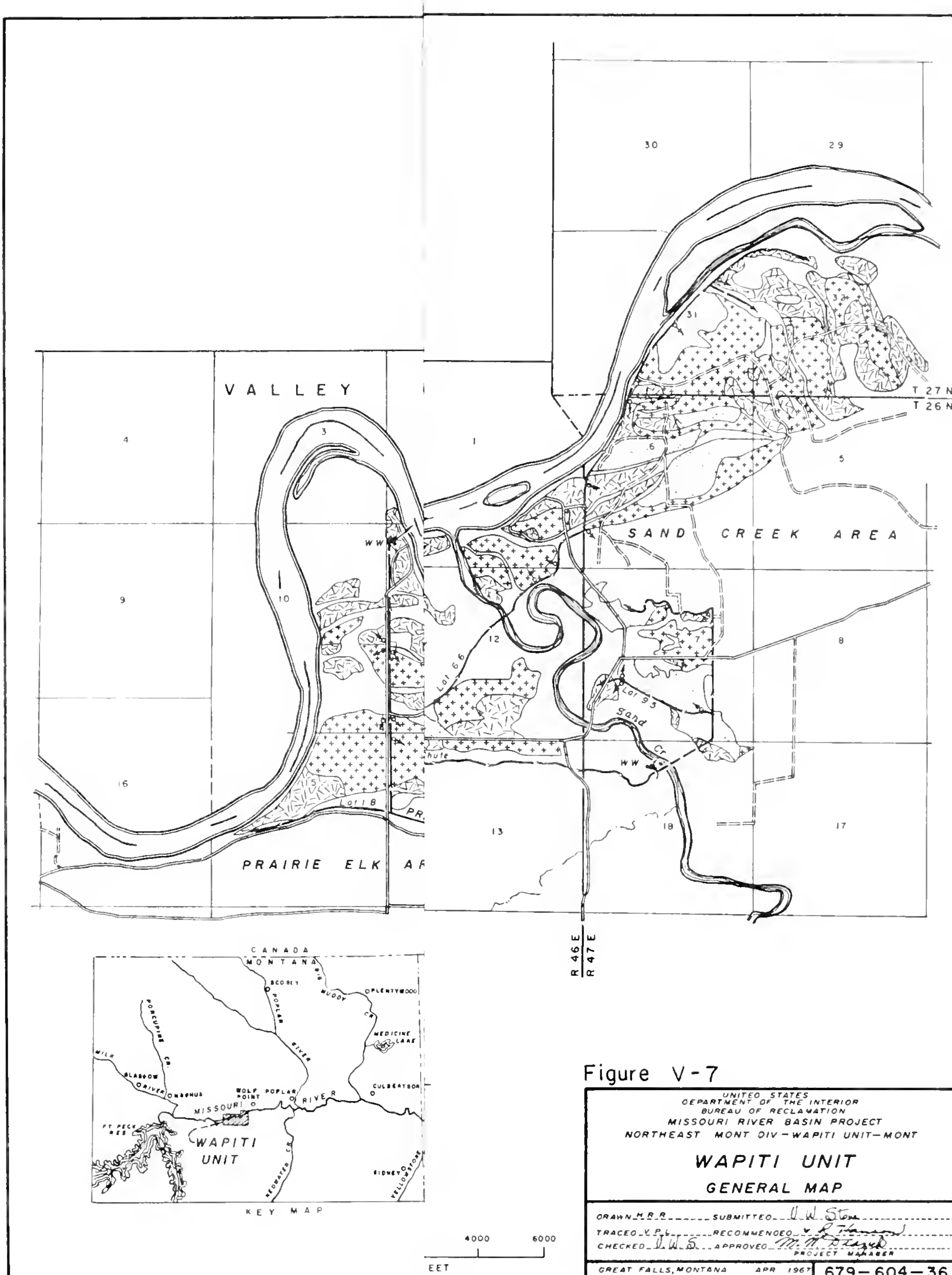
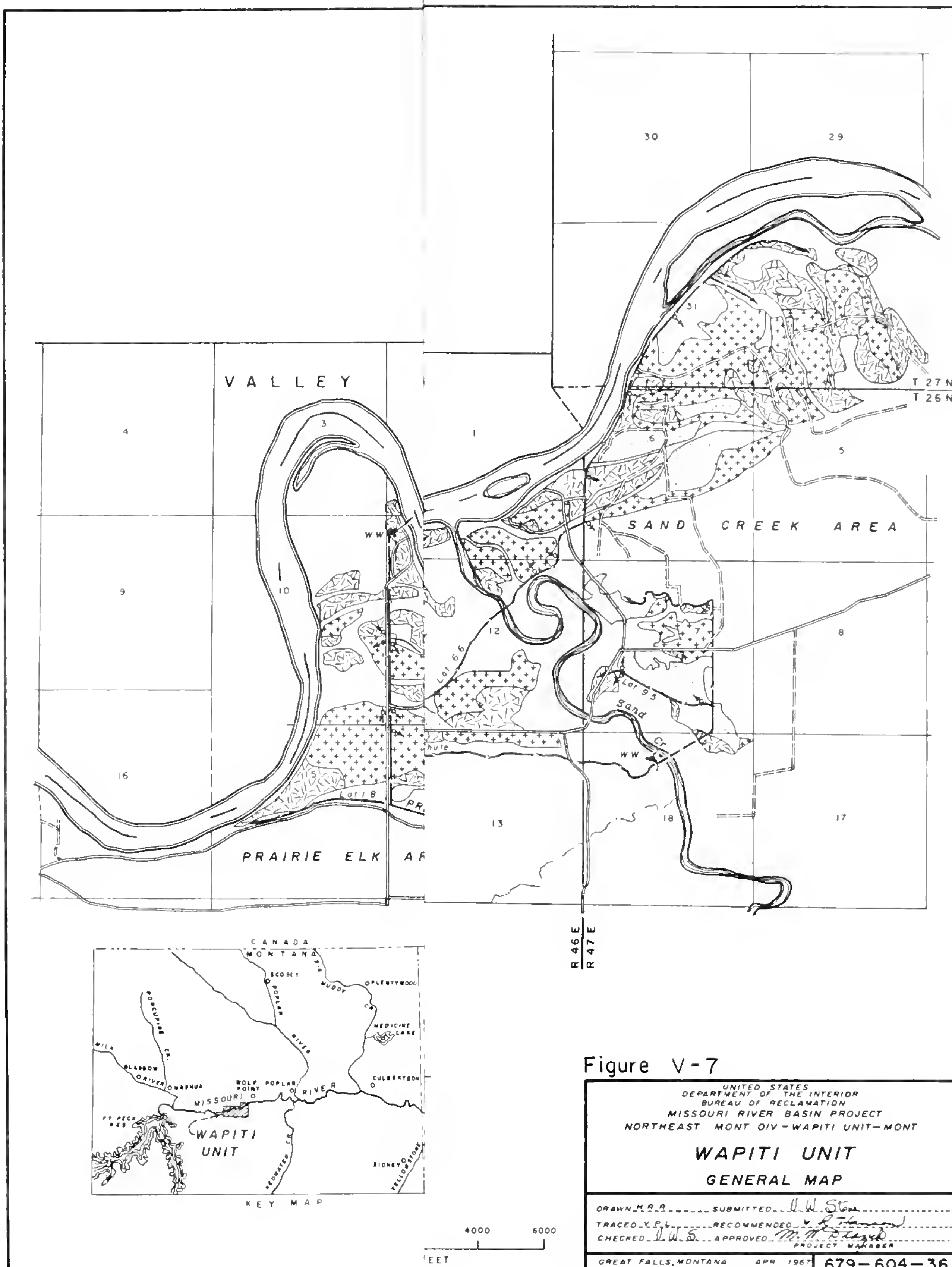

VALLEY
SAND CREEK AREA
PRAIRIE ELK AR
30
29
31
T 27 N
T 26 N
4
3
1
6
5
9
10
12
8
16
13
18
17
WW
Lot 66
Lot 93
Lot 18
Sand Cr
R 46 E
R 47 E
CANADA
MONTANA
SCOBEY
PLENTYWOOD
BIG MUDDY CR
POPLAR RIVER
MEDICINE LAKE
PORCUPINE CR.
MILK
GLASGOW
NASHUA
WOLF POINT
POPLAR
MISSOURI RIVER
CULBERTSON
FT PECK RES
WAPITI UNIT
REDWATER CR.
SIDNEY
YELLOWSTONE
KEY MAP
4000
6000
EET
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV – WAPITI UNIT – MONT
WAPITI UNIT
GENERAL MAP
DRAWN M.R.R. SUBMITTED U. W. Stone
TRACED V.P.L. RECOMMENDED
CHECKED U.W.S. APPROVED
PROJECT MANAGER
GREAT FALLS, MONTANA APR 1967 679–604–36

Figure V-7


VALLEY
SAND CREEK AREA
PRAIRIE ELK AR
T 27 N
T 26 N
R 46 E
R 47 E
Lat 66
Lat 95
Lat 18
Sand Cr.
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30
29
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4
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10
12
8
16
13
18
17
CANADA
MONTANA
SCOBEY
PLENTYWOOD
MEDICINE LAKE
CULBERTSON
GLASGOW
WOLF POINT
POPLAR
MISSOURI
RIVER
FT. PECK RES.
WAPITI UNIT
SIDNEY
KEY MAP
4000
6000
FEET
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV - WAPITI UNIT - MONT
WAPITI UNIT
GENERAL MAP
DRAWN M.R.R. SUBMITTED
TRACED V.P.L. RECOMMENDED
CHECKED APPROVED
PROJECT MANAGER
GREAT FALLS, MONTANA APR 1967
679-604-36

Figure V-7

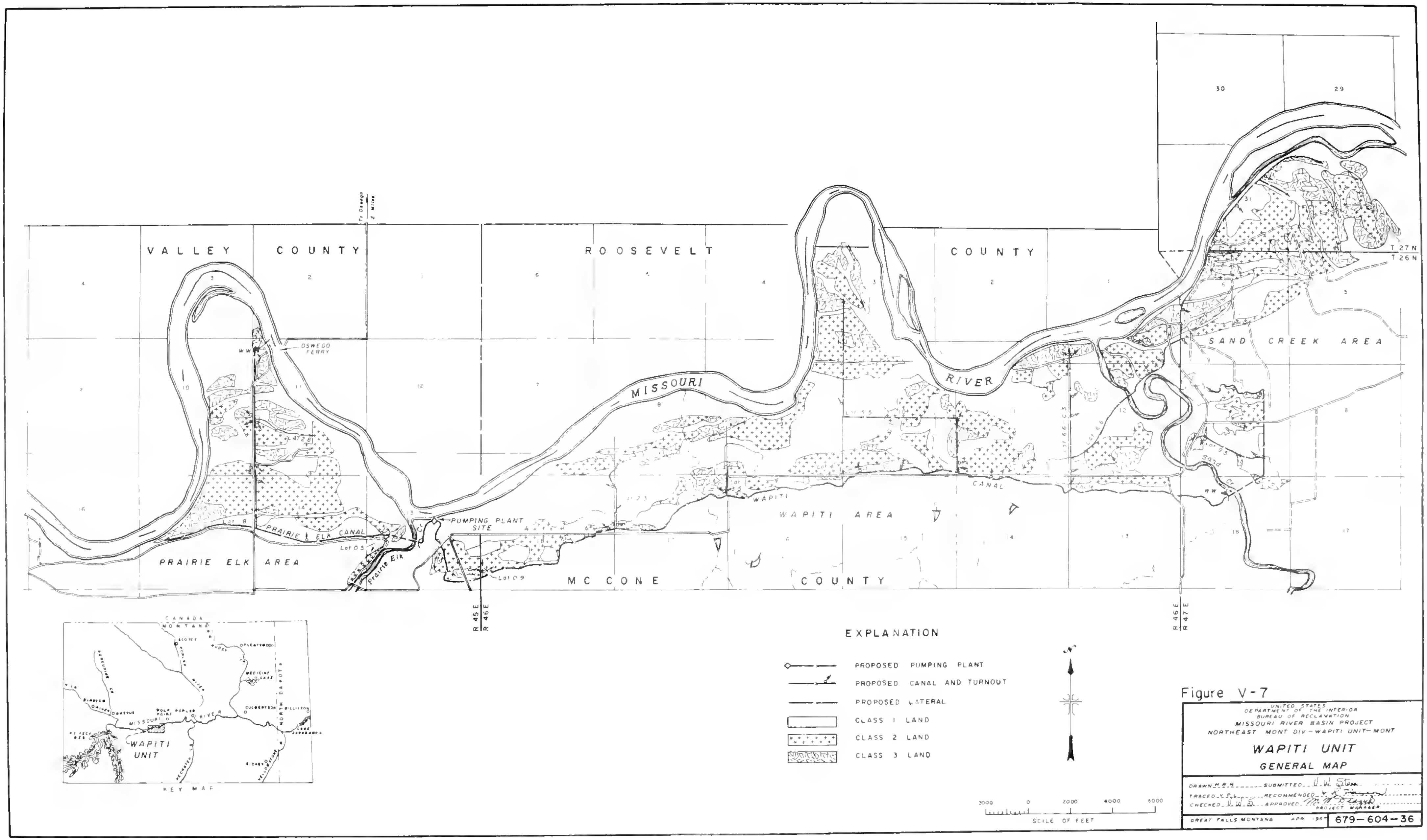

VALLEY COUNTY
ROOSEVELT COUNTY
MC CONE COUNTY
MISSOURI RIVER
OSWEGO FERRY
To Oswego 2 Miles
PRAIRIE ELK CANAL
PRAIRIE ELK AREA
Prairie Elk Cr.
PUMPING PLANT SITE
WAPITI CANAL
WAPITI AREA
SAND CREEK AREA
Sand Cr.
T 27 N
T 26 N
R 45 E
R 46 E
R 46 E
R 47 E
EXPLANATION
PROPOSED PUMPING PLANT
PROPOSED CANAL AND TURNOUT
PROPOSED LATERAL
CLASS 1 LAND
CLASS 2 LAND
CLASS 3 LAND
N
2000 0 2000 4000 6000
SCALE OF FEET
CANADA
MONTANA
MISSOURI RIVER
MEDICINE LAKE
NORTH DAKOTA
WAPITI UNIT
KEY MAP
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV - WAPITI UNIT - MONT
WAPITI UNIT
GENERAL MAP
DRAWN
SUBMITTED
TRACED
RECOMMENDED
CHECKED
APPROVED
PROJECT MANAGER
GREAT FALLS MONTANA
679-604-36

Figure V-7

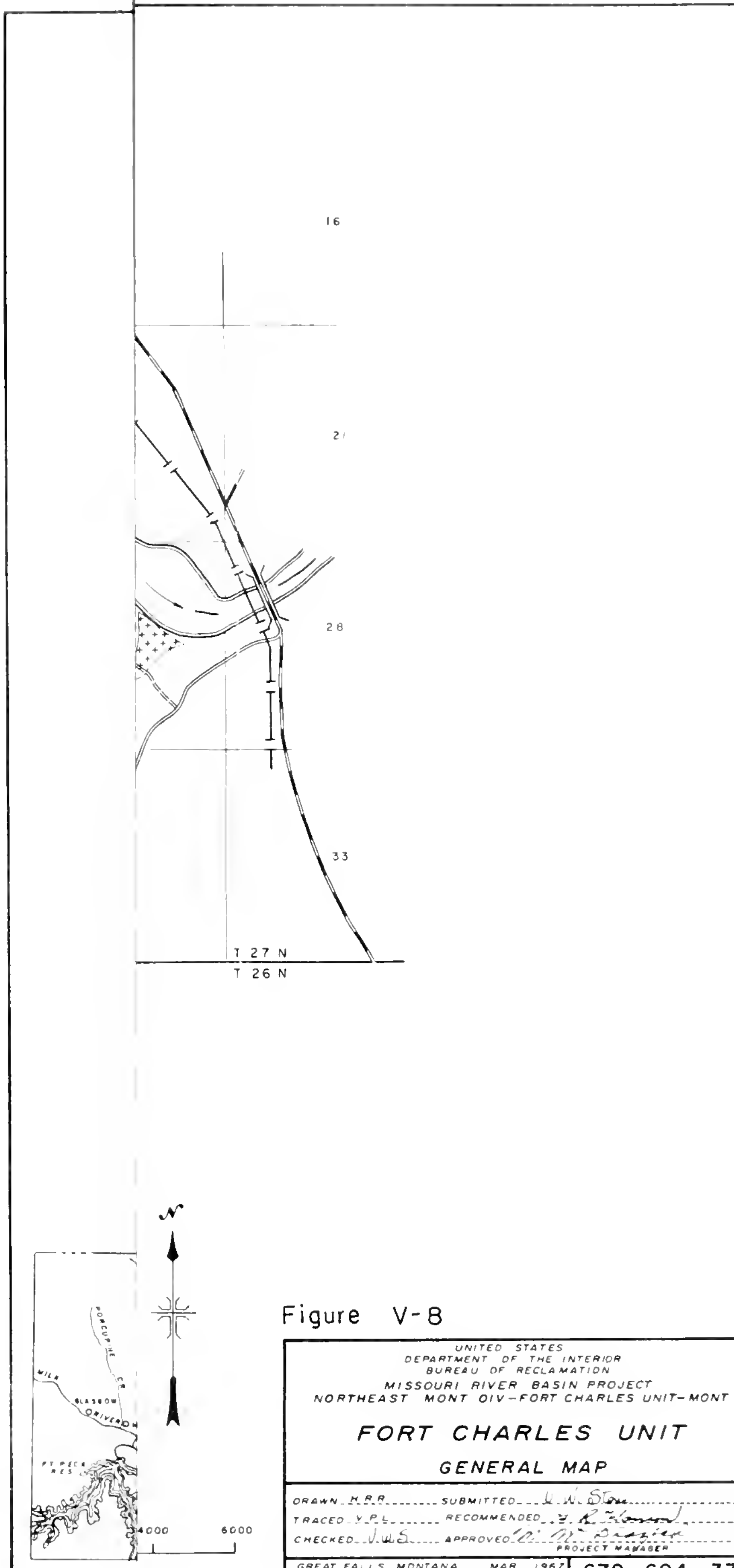


Figure V-8

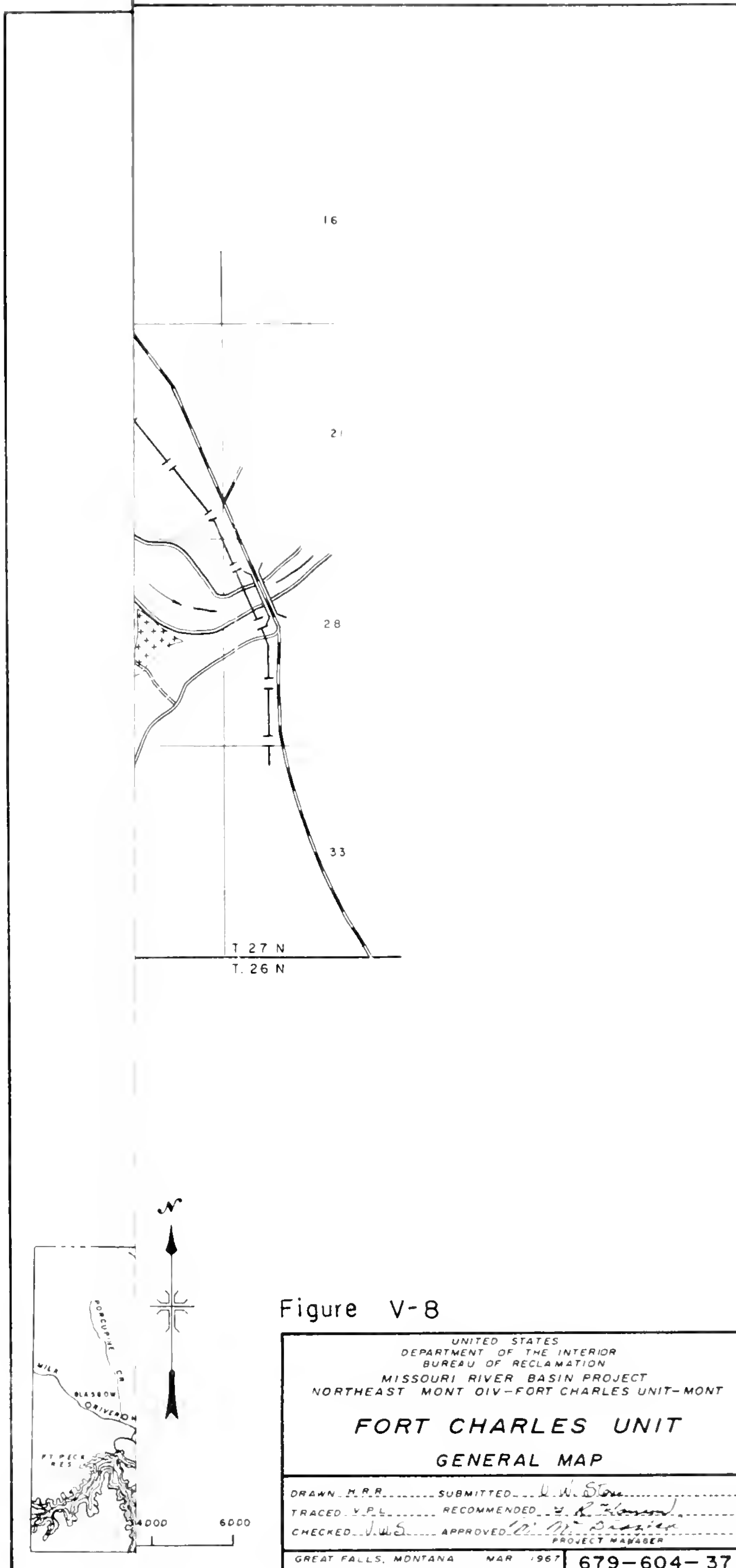
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV - FORT CHARLES UNIT - MONT

FORT CHARLES UNIT

GENERAL MAP

DRAWN M.R.R. SUBMITTED U. W. Stone
TRACED V.P.L. RECOMMENDED V. R. Kunecel
CHECKED U.W.S. APPROVED W. M. Brazier
PROJECT MANAGER

GREAT FALLS, MONTANA MAR 1967 679-604-37


16
21
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T. 27 N
T. 26 N
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PORCUPINE CR
MILK
GLASGOW
RIVER
FT. PECK RES.
4000
6000
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV–FORT CHARLES UNIT–MONT
FORT CHARLES UNIT
GENERAL MAP
DRAWN H.R.R. SUBMITTED U. W. Stone
TRACED V.P.L. RECOMMENDED
CHECKED U.W.S. APPROVED
PROJECT MANAGER
GREAT FALLS, MONTANA MAR 1967
679–604–37

Figure V-8

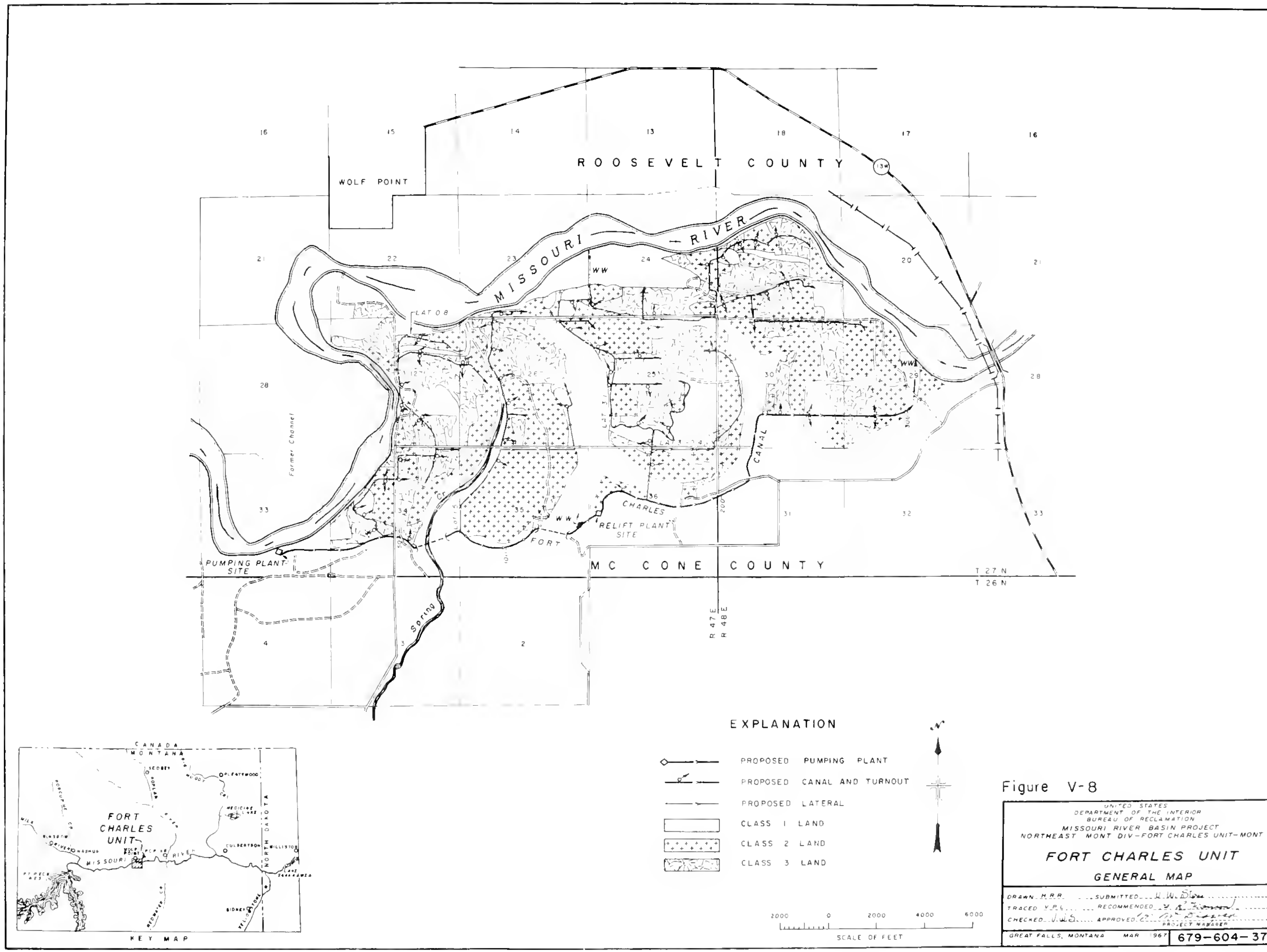


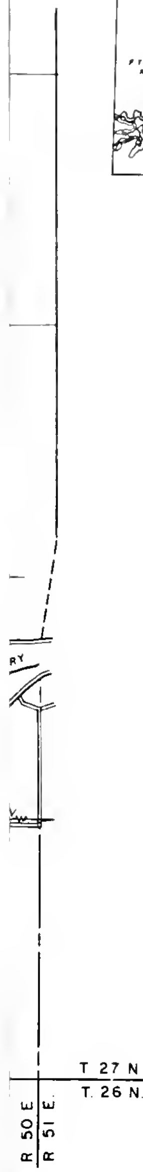
Figure V-8

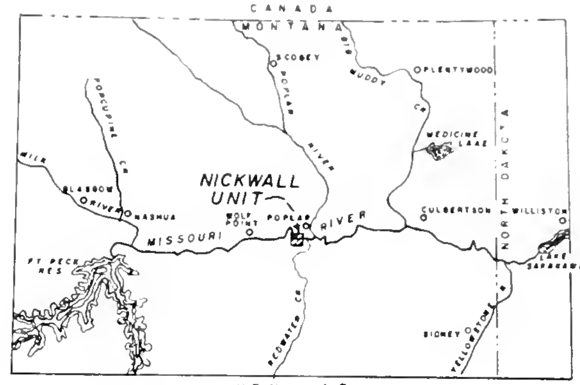
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV-FORT CHARLES UNIT-MONT

FORT CHARLES UNIT
GENERAL MAP

DRAWN H.R.R. SUBMITTED
TRACED RECOMMENDED
CHECKED APPROVED
PROJECT MANAGER

GREAT FALLS, MONTANA MAR 1967 679-604-37





KEY MAP

Figure V-9

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV – NICKWALL UNIT – MONT

NICKWALL UNIT

GENERAL MAP

DRAWN H.R.R.	SUBMITTED V. W. Stone
TRACED V.P.L.	RECOMMENDED T. R. Hansen
CHECKED V.W.S.	APPROVED M. M. Stasch, PROJECT MANAGER
GREAT FALLS, MONTANA MAR 1967	679–604–38

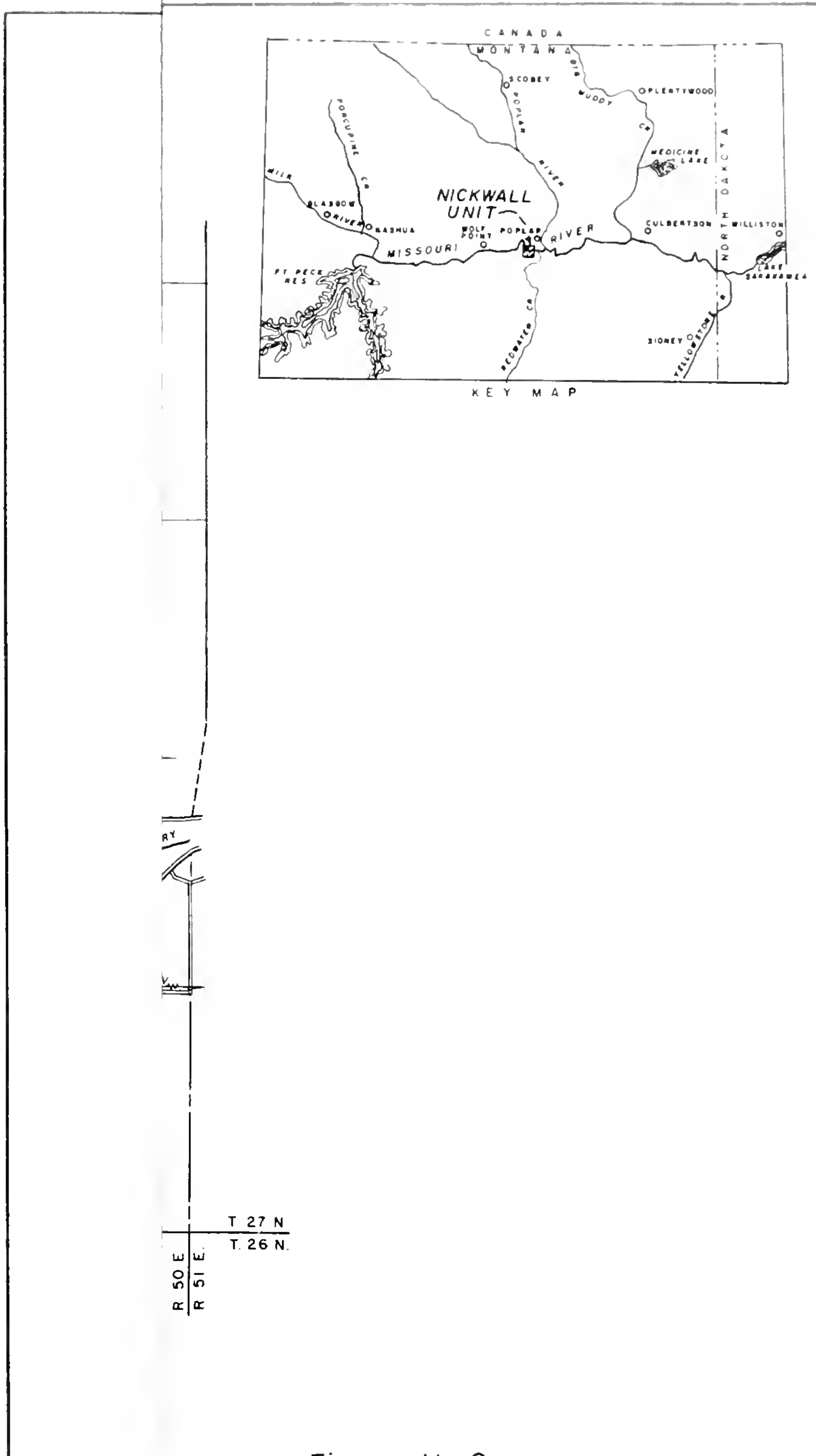


Figure V-9

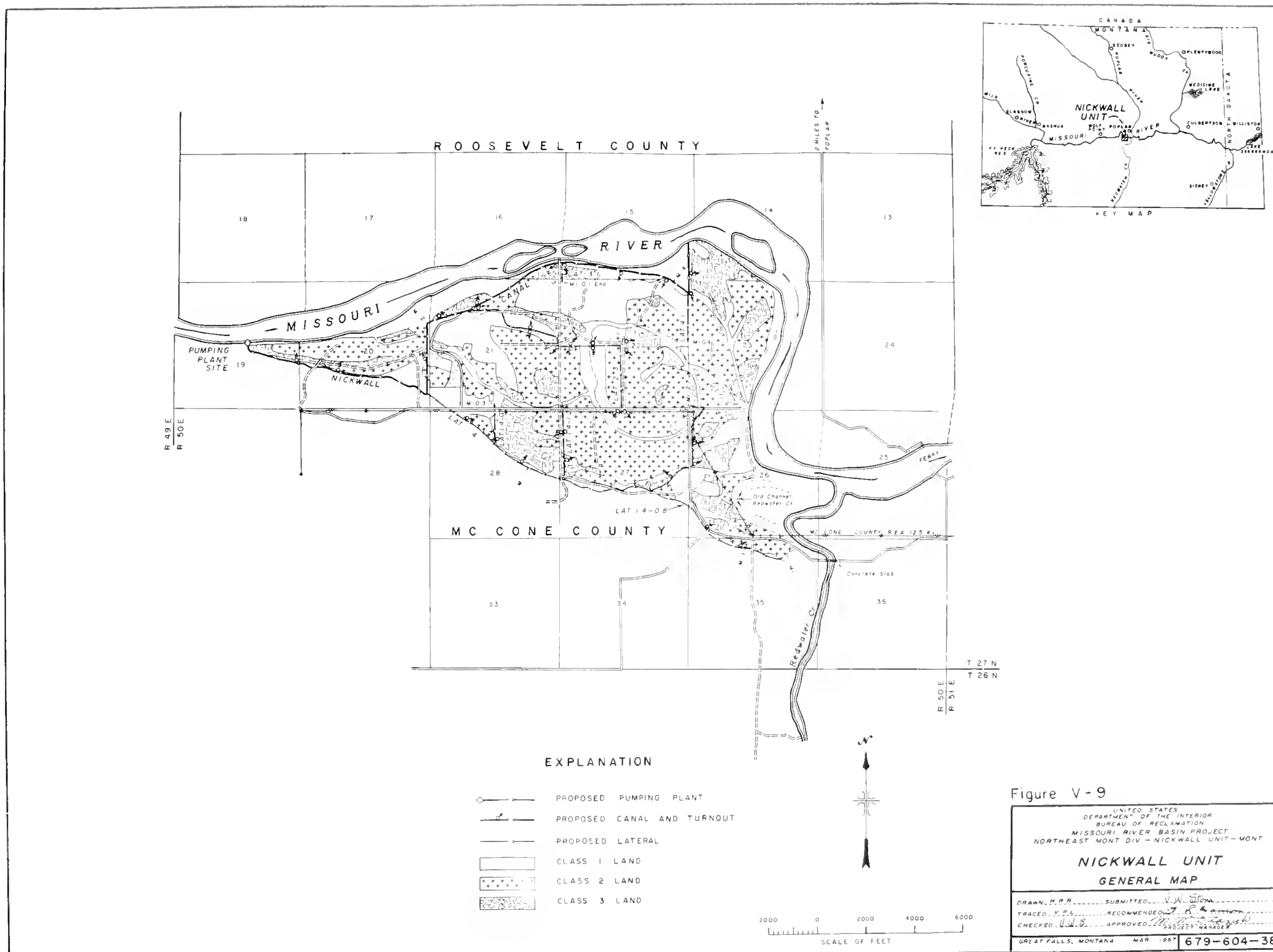
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV – NICKWALL UNIT – MONT

NICKWALL UNIT

GENERAL MAP

DRAWN H.R.R. SUBMITTED V.W. Stone
TRACED V.P.L. RECOMMENDED T. R. Hanson
CHECKED U.W.S. APPROVED M. W. [illegible]
PROJECT MANAGER

GREAT FALLS, MONTANA MAR 1967 679–604–38



ROOSEVELT COUNTY
MC CONE COUNTY
MISSOURI
RIVER
PUMPING PLANT SITE
NICKWALL
CANAL
2 MILES TO POPLAR
Old Channel Redwater Cr
Redwater Cr
LAT 14-08
Concrete Slab
FERRY
MC CONE COUNTY R.E.A. 12.5 KV
T 27 N
T 26 N
R 49 E
R 50 E
R 51 E
KEY MAP
CANADA
MONTANA
NICKWALL UNIT
NORTH DAKOTA
EXPLANATION
PROPOSED PUMPING PLANT
PROPOSED CANAL AND TURNOUT
PROPOSED LATERAL
CLASS 1 LAND
CLASS 2 LAND
CLASS 3 LAND
2000 0 2000 4000 6000
SCALE OF FEET
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
NORTHEAST MONT DIV – NICKWALL UNIT – MONT
NICKWALL UNIT
GENERAL MAP
DRAWN H.R.R. SUBMITTED
TRACED V.P.L. RECOMMENDED
CHECKED W.W.S. APPROVED
PROJECT MANAGER
GREAT FALLS, MONTANA MAR 1967
679-604-38

Figure V-9

annual diversion requirement was calculated at 2.85 acre-feet per acre, of which 1.1 acre-feet would be return flow. A diversion period of April to October was considered. Operation of the 9,630 acre system would be conducted from a headquarters near the Fort Charles Unit.

Fair comparison of the estimated costs, as given in the U.S. Bureau of Reclamation report, with those calculated for the pumping plans from Fort Peck Reservoir would require detailed study. The U.S. Bureau of Reclamation costs cover complete systems which would provide gravity supply and drainage to the land served. The highly preliminary plans for the pumping from Fort Peck Reservoir which are discussed later, generally supply water in stream channels. The U.S. Bureau of Reclamation construction costs given below are as of January, 1967:

Unit	Acreage Served	Construction Cost
Farmer Creek	840	$ 213,000
Wapiti	3,540	2,332,000
Fort Charles	3,060	1,828,000
Nickwall	2,190	1,002,000
	9,630	$5,375,000

The above construction costs would average about $560 per acre irrigated. Annual repayment, over a 40-year period at 5 1/2% interest, would cost about $33 per acre. Annual operation and maintenance was calculated at $5.59 per acre served. A lessening of these costs might be obtained by redesign of the proposed systems. For instance, extensive use of sprinkler irrigation might well result in lower ditch construction costs, because of the need for less water and a decrease in estimated drainage costs, resulting from less water being applied to the land.

In addition to the above four units, several other areas were considered suitable for irrigation. Investigations of these were deferred, for lack of local interest or other reasons. An N-Bar-N unit, which may comprise about 3,200 acres, could serve the bottom land between the Farmer Creek and Wapiti Units. A Redwater Unit, of about 840 acres, is largely in the northeast corner of Richland County, near the mouth of the Redwater River. A Charley Creek Unit could serve about 820 acres in Range 53E, upstream from the mouth of Charley Creek.

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Pumping from the Missouri River, to serve a substantially larger acreage than the four separate units considered by the U.S. Bureau of Reclamation, was studied. The plan would serve 14,000 acres in the Nickwall and Sheep Creek basins and the lower lands along the west side of the Redwater River, downstream from Wolf Creek. It would include the Nickwall and Redwater units, previously mentioned in the U.S. Bureau of Reclamation plans. McCone Plan B, as developed later in this report, would have approximately the same irrigated acreage in the Nickwall and Sheep Creek basins, and also serve the Wolf Creek basin through pumping from Fort Peck Reservoir.

The highly preliminary costs developed for this plan show a construction cost of about $4,000,000 or $286 per acre irrigated. The relatively favorable cost of this plan indicates that it should be studied in closer relationship to McCone Plans A and B.

D. FORT PECK RESERVOIR PUMPING AND WATER DELIVERY PLANS

General

The size, location and relative elevation of Fort Peck Reservoir, with respect to the irrigable lands of the study area, indicates that a large part of the engineering investigations should be devoted to alternate plans of pumping from that water body. In addition, as explained in Chapter I, the original application and definition of the preliminary feasibility study called for a preliminary feasibility assessment of using water from Fort Peck Reservoir for water developments in the study area.

This multipurpose reservoir, it should be noted, is subject to a considerable range of stage. For purpose of this study, it has been assumed that the water surface may be drawn to an elevation of 2,200 feet during the irrigation season, following a series of low runoff years, such as occurred in 1960 and 1961. Under average conditions, however, the water level would probably fluctuate between 2,230 and 2,245 feet elevation. In serious flood periods the water level could conceivably be slightly higher than the 2,250 feet elevation, which is equivalent to a water level reaching the top of the 25-foot spillway gates.

Basic Description of Engineering Systems Considered

Securing water from Fort Peck Reservoir and conveying it to the points of use in the study area presents a number of complex problems.

Although this study was intended to be of a preliminary nature, it was, to some degree, hampered in detailed engineering work, because of the lack of adequate maps. The Army Map Service has issued maps covering the study area on a scale of one-quarter inch to the mile, and contour intervals of 100 feet. The precise selection of pumping sites and canal locations on such maps is necessarily difficult and inconclusive. The few available U.S. Geological Survey topographic maps were useful for some parts of the routings in Garfield County. An extensive use was made of aerial photography, barometric levelling and field reconnaissance, by the study staff, to supplement the map coverage.

High lifts and large volume pumping is definitely required to provide gravity flow to the general areas of use and to provide irrigation water as economically as possible to the study area. The minimum static lift, which was given detailed study, was 300 feet, with a discharge capacity of 59 cubic feet per second (cfs). Static lifts as high as 900 feet were considered. The largest pump capacity incorporated into any of the preliminary engineering plans was 540 cfs.

The seasonal use and high peak demand of hot and dry summer months make it desirable, in some plans, to provide storage and thereby require less pumping equipment capacity.

Efficient high head and high capacity pumps require a positive suction head of about 50 feet. This means that any pumphouse structure at Fort Peck Reservoir must be located over the water and that the pump bowl would need to be at approximately 2,150 feet elevation. By using an initial low lift to a small reservoir, the first pumphouse could be located nearer the shore, but still over the water. The highly preliminary cost estimates used for pump costs, in this study, indicated that the latter system would probably be the least expensive.

Relift stations were selected in cases where the total pumping head was over 500 feet. Pressure pipelines are proposed or considered to carry the water, by the shortest apparent distance, to a ridge or drainage divide. Storage reservoirs do permit some reduction in the size of pumping equipment and pipelines, with respect to water requirements of hot summer months.

The description of the individual plans and the cost estimates outlined below are all based on the use of a high-head initial lift at Fort Peck Reservoir.

Most canals are layed out or primarily conceived to follow ridges to points where water could be released into stream channels. It is further assumed that individual irrigators would then divert from the streams by either canals or pumping systems or a combination of both.

The potentially irrigable acres of the study area, as discussed in detail in Chapter III, are scattered and generally lie in or near stream channels. The largest irrigable tracts, within reach of the proposed systems, are in the broader valleys. The preliminary plans do not include the canals or private pumping systems which will be required to divert water and apply it to the individual lands.

The number of acres included in each of the pumping project plans was based upon the potentially irrigable lands as discussed and tabulated in Chapter III and their proximity to the irrigation water supply. Although the detailed soil survey maps showed the location and size of the potentially irrigable tracts, the lack of detailed contour maps of elevation made it necessary to exercise judgment as to which acres should be included in irrigation plans. The general rules of thumb used were that: (1) the irrigated land be within one-half mile of the water supply and (2) the additional private pumping lifts be less than about 100 feet. Some potentially irrigable lands, which apparently did not meet the preceding guidelines were included. This was done only if it appeared reasonable for private interests to construct a gravity canal to serve a tract or several closely spaced tracts of land, totalling more than about 160 acres. The application of the preceding guidelines was generally conservative, with the intention of avoiding any overall reduction in the acreage to be irrigated, when, and if, a detailed feasibility study is undertaken.

The plans included in this study should be regarded as preliminary. Detailed feasibility studies would undoubtedly be required to develop plans upon which final judgments could be based. More detailed mapping and soil tests may change some canal routings and the feasibility or extent to which some streams may ultimately be used for conveyance channels. More detailed data may disclose the desirability of extending some of the plans to include areas that were preliminarily dismissed. As an example,

extensions to serve the Brockway and Pasture Creek areas may eventually prove beneficial, through extension of either McCone Plan A or McCone Plan B.

Recognition of Irrigation Water Needs

The estimated water requirements for irrigation were based largely upon Bulletin 494, issued by the Montana Agricultural Experiment Station at Montana State University. Crops for livestock feed production were considered to be the principal users of the irrigation water. An annual consumptive use of 25 inches was assumed for each irrigated acre. Effective precipitation would reduce the irrigation requirement to a yearly average of 18 inches. It was assumed that the irrigation efficiency would be 70 percent, in view of high water costs and area soils. This would result in a water need of nearly 26 inches or 2.14 acre-feet per irrigated acre per year. Adjusting the monthly consumptive use for precipitation, resulted in the following average farm diversion requirements, as assumed in this study:

April	12 percent	0.26 acre-feet
May	14	0.30
June	14	0.30
July	23	0.49
August	22	0.47
September	15	0.32
Total growing season	100 percent	2.14 acre-feet

Local streamflow was not considered, although it may, at times, lessen the pumping needs and consequent operating costs. Additional storage of the highly variable local streamflow would be required, if the pumping and conveyance capability of the various plans were reduced. A detailed feasibility study should include investigation of this matter, because of the significant impact, which it may have on water costs.

Recognition of Municipal Water Needs

Providing water from Fort Peck Reservoir for municipal use was incorporated into the plans, wherever it was physically possible. In all instances, streams would be used for conveyance of the water for a number of miles. This would, undoubtedly, have an effect on the ultimate chemical quality and turbidity of the water. The large pumps would not be operational in the winter season and, thus, storage

for municipal use would be required. This storage would probably be in a reservoir designed for that specific purpose. It may, however, be possible to combine storage for municipal needs with storage for irrigation. The anticipated storage reservoirs would also serve as settling ponds. Repumping of water would likely be required for pressure delivery to municipal users. Chlorination of the water would be required and the necessity may exist to provide additional treatment to reduce turbidity.

The estimates for Garfield Plans A and C include the approximate construction cost of facilities to deliver untreated water to the present Jordan municipal storage tank. McCone Plans A and B provide seasonal water supply in the Horse Creek channel for rediversion to Circle. The present inadequacy of municipal water storage at Circle and the alternatives of bringing water into Circle did not appear to justify a cost estimate in this preliminary survey. The quantity of water that would be used by either Jordan or Circle would be such a small part of the total quantity to be pumped from Fort Peck Reservoir under the proposed plans, that it would have no material effect on the cost estimates of this preliminary survey.

Recognition of Industrial Water Needs

The coal resources and their utilization, as discussed in detail in Chapter IV, were considered in the water use plans. The sale of water to private industry, developing electrical power from the strippable coal, appeared to be a logical preliminary assumption. Conversion of coal to liquid crude and synthetic gas, as well as electrical power, could become practical. The quantity of water needed could vary widely with the size of the industrial development and nature of the process. Available information on the strippable coal resources indicates that the Weldon-Timber Creek coal deposits might be attractive to private industry for local generation of electrical power.

Proposed McCone systems incorporate an assumption of a water use of about 7,200 acre-feet per year in the Weldon-Timber Creek area. This is based upon stream and cooling requirements for a conventional 500 MW electric power generation plant. Some of the cooling water might be re-used for irrigation. Yearly industrial use of up to 25,000 acre-feet in the Weldon-Timber Creek area would have no material effect on estimated construction costs. Some increase in the size of proposed conveyance facilities might be required,

however, in combination with additional storage for industrial water delivery to the Redwater coal deposits, near Circle, or the Carroll and Lane deposits of Dawson and Richland Counties. Preliminary information on coal investigation in Garfield County, indicates strippable coal within reach of the proposed Garfield systems; however, plans do not warrant present consideration.

Water sale to industry could, it should be emphasized, have a very favorable effect on water costs for irrigation and feasibility of the McCone plans. Facilities required for the high seasonal irrigation use may require little or no revision to supply additional water for potential, year-around industrial requirements. The uncertainty of the quantities of water, which may be required by industry and the specific areas of their use, could result in a confusion of examples of the corresponding effect on irrigation costs. The economic comparisons, included in this and later chapters, are generally confined to examples of an assumed industrial use of 7,200 acre-feet per year in the Weldon area, after the first lift from Fort Peck Reservoir. The rather wide range of acre-foot charges, included in later analyses, will assist in assessing the effect of industrial water sale, assuming various quantities and prices. Estimated annual pumping costs, given later in this chapter, would vary directly with any change in total water pumped, as well as any change in the required lift.

Recognition of Recreational Water Needs

The relatively high cost of delivered water appears to place limitations on the inclusion of specific recreation and wildlife features in the plans of this preliminary survey. Some incidental benefits are, however, apparent. The habitat of water fowl and game birds would be improved. Maintaining sustained flow of improved quality in a number of streams, during the irrigation season, would provide fishery and related recreational benefits. Return flows would probably be adequate to maintain some live streams throughout the year. Winter releases from reservoirs could be scheduled to improve winter streamflow, if the cost was justified. The absence of any specific recreational structures or provisions, in the alternate plans presented in this preliminary study, should not be interpreted as a disregard or dismissal of the importance of recreation to the area's total water development. The maps and other information which were available for this preliminary study were not considered adequate for specific recreation planning. The detailed feasibility study, which

is the next step in conservancy district establishment, should include specific information necessary for fair appraisal and recommendations concerning development of recreational potential.

Purpose and Basic Approach to Engineering Systems Considered

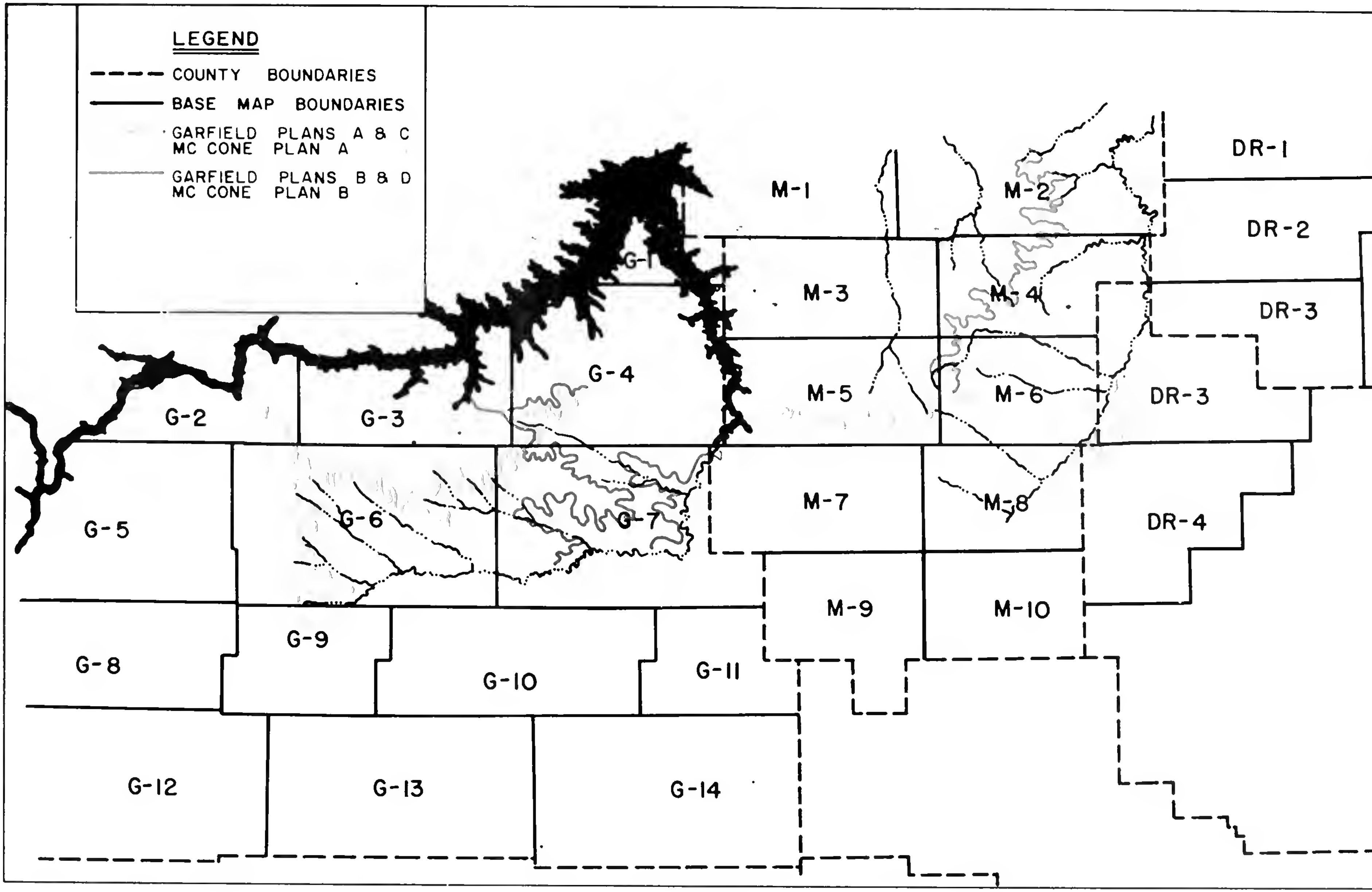
The purpose of this preliminary survey was to identify and study plans that appear, on a preliminary basis, to offer the greatest total water development to the area, at the least cost. Highly preliminary alternatives were examined and the more favorable of these were studied in greater detail. Four alternative plans (Plans A, B, C and D) were studied and are reported on for Garfield County. The rather narrow range of costs per irrigated acre in the four plans for Garfield County illustrates the extensive consideration given before a possible alternative was tentatively rejected.

Two plans were closely studied for McCone and adjacent areas of Dawson and Richland Counties (Plans A and B). Results of extending these systems to serve a larger area were tested sufficiently to determine their effect on per acre costs of irrigation. A limited discussion is presented for alternatives, which were briefly studied and dismissed in McCone County.

The topography of the area made it obvious that separate pumping diversions from Fort Peck Reservoir should be studied for Garfield County and the areas to the east in McCone, Dawson and Richland Counties. The discussion which follows is presented along these lines to improve clarity. This method of visual presentation, of the proposed systems, is in no way intended to imply that the entire study area should logically be divided in an identical manner, as concerns the establishment of conservancy district boundaries. This method of presentation is used only to illustrate the proposed alternate systems, as studied.

Sub-Area Orientation

The arrangement of the various descriptive plates for the sub-areas was discussed in detail in Part C of Chapter III. Detailed maps (plates) showing the alternate water-use plans, by sub-area, and their relationship to potentially irrigable land, present land use and present land ownership, appear in the accompanying Detailed Map Assembly. Figure V-10 is a key map showing the general location of the alternate water-use plans and the locational plate



KEY MAP OF IRRIGATION SYSTEMS

Figure V-10

Scale: 1:1,000,000
1 inch equals approx. 16 mi.

designation of each of the 28 sub-areas. The color pattern of the irrigation systems on the key map is also used in the corresponding plates, which are found in the Detailed Map Assembly. The letter "G" means a particular sub-area is in Garfield County, "M" is used for McCone County and "D-R" indicates Dawson and Richland Counties. The detailed plates carry the full name of the counties. As indicated in Chapter III, the number following the letter designation, on the key map, further identifies the sub-area, as well as the map order, within the county groupings. The plates carry a second number to identify the characteristics that are being compared. These group numbers are: 3 for "ALTERNATE IRRIGATION SYSTEMS - POTENTIALLY IRRIGABLE LAND", 4 for "ALTERNATE IRRIGATION SYSTEMS - PRESENT LAND USE", 5 for "ALTERNATE IRRIGATION SYSTEMS - PRESENT LAND OWNERSHIP".

An additional example of the detailed map location may be helpful. McCone County Plate 5:3 shows the proposed irrigation systems in relationship to potentially irrigable land for sub-area M-5, as indicated by the key map (Figure V-10). McCone County Plate 5:4 shows the proposed irrigation system and present land use for the same sub-area. McCone County Plate 5:5 shows the proposed irrigation system and present land ownership.

Present irrigated land, within the study area, is presented in Section III of the accompanying Detailed Map Assembly. All descriptive plates referring to ("PRESENT IRRIGATED LAND") are labeled as 6A. As an example, present irrigated land, within McCone County Sub-Area 5 (M-5), would appear on McCone County Plate 5:6A in the Detailed Map Assembly.

The text material, which immediately follows, describes the proposed Garfield County systems. This is followed by the proposed McCone County systems, which also serve parts of Dawson and Richland Counties. The system plan descriptions are, then, followed by an explanation of the cost criteria, which were used in estimating construction and annual operation and maintenance (O & M) costs. The construction and annual O & M costs are then tabulated separately for each of the proposed Garfield and McCone systems.

Garfield County Plans A and C

In its entirety, Plan A is the most ambitious of the four plans considered for Garfield County. The primary objective of the system is to irrigate as much land as

possible, without being completely unrealistic as to where water is delivered in the area. Because of the terrain and the scattered location of the potentially irrigable lands, a conventional system of feeder canals and laterals would be impractical. It seems more advantageous or logical to use feeder canals riding the higher ridges and divert water into natural stream channels from these canals. The individual farmer would then take water from the natural stream or smaller canals. Garfield Plan A would provide water for the irrigation of about 21,360 acres.

Garfield Plan C is essentially the same as Plan A, except that the Woody Creek irrigation has been eliminated, with a subsequent reduction in the cost resulting. The plan would serve 17,650 acres. The features of Plan A are all applicable to Plan C, except as noted for Woody Creek.

The first lift pumping station for these plans is tentatively planned for the Seven Blackfoot Creek inlet of Fort Peck Reservoir in Section 1, T21N, R33E (Garfield County Plates 2:4 and 2:5 of the Detailed Map Assembly). This initial pump station would be supported over the reservoir at that location. A second lift pumping station would be required, about 450 feet above the lake, to divide in half the total static lift of 900 feet. A detention pond, capable of holding enough water for one hour's operation of the second lift pump, has been included in the plan. A 72-inch pressure pipeline of 3.1 miles would take the water from the first lift station to the second lift station and, then, on up to the beginning of the main canal, at the head of Billy Creek.

From the head of Billy Creek, this main canal would follow the Seven Blackfoot-Snow Creek divide to the head of Snow Creek, where an open cut or tunnel would be required to get the water through the Smoky Butte-Snow Creek divide and into the head of Smoky Butte Creek. A 20,000 (Plan A) or 15,000 (Plan C) acre-foot storage reservoir is planned for Smoky Butte Creek, with the top elevation at about 3,000 feet. This reservoir, with an earth dam and wet-well type outlet control, would serve as the primary regulating reservoir of Plan A and the only regulating reservoir of Plan C.

The outlet works from this reservoir would discharge into a diversion headworks that would distribute water into three main conduits. The first of these is a canal with a generally south direction, serving Lone Tree Creek and carrying water as far as Steve's Fork. The second main

diversion would be into Smoky Butte Creek, to serve the Smoky Butte Creek and Big Dry Creek bottom lands. The third diversion is into the East Canal, which meanders around various smaller ridges just below the main divide, between the Big Dry and the Hell Creek drainages. This canal delivers water into Vàil and Frazier Creeks and supplies water to Jordan via a smaller storage reservoir on Vail Creek. Under Garfield Plan A, the East Canal would terminate in a 6,000 acre-feet storage reservoir on Wolf Creek, at an elevation of approximately 2,800 feet. This reservoir would serve as the source for a re-pump station to pump water into the Woody Creek area, as well as supplying water to Wolf Creek Under Garfield Plan C, the East Canal would simply drop or flow into Wolf Creek.

Details on acreage served, pumping plant data, canal sizes and lengths, stream channel use and total volume pumped per year are listed in Table V-E. Reference to the sub-area key map (Figure V-10) and the more detailed map sets of Garfield County Plates 3, 4 and 5 is suggested. These detailed plates appear in Section II of the accompanying Detailed Map Assembly.

Garfield County Plan B

Another engineering study in Garfield County focused upon serving the Woody Creek area and the lower portion of the Big Dry Creek bottom land. The plan would serve about 9,770 acres.

The first lift pumping plant for this system is located in the Hell Creek area of Fort Peck Reservoir, in Section 29, T22N, R38E (Garfield County Plates 3:3, 3:4 and 3:5 of the Detailed Map Assembly). Two 150 cfs pumps, one a standby, would have to be supported over the reservoir in an intake structure. Sixty-inch pressure pipe would be required to lift the water to the second lift station, 300 feet higher, at an elevation of 2,500 feet. A small detention pond would be required to insure continuous flow of water into the second lift and to protect the second-lift pumps. A total of 6.5 miles of pressure pipe would be required to get water from Fort Peck Reservoir to the first point of diversion or use.

At the end of the pressure pipe, located on the flats at the head of the North Fork of Woody Creek, the water would pass through a transition structure - diversion head-works combination. This first diversion would be into a long southerly canal, which would serve the South Fork of

Woody Creek, lower Frazier Creek and the lower end of the Big Dry. Water let past this first headworks would go into a chute, or well-protected natural stream channel, to a second diversion structure about a mile downstream. This structure would divert some water into an East Canal, about 20 miles long, which would serve the Pass Creek area. The rest of the water would be allowed to go into Woody Creek and irrigate the bottom lands along Woody Creek.

Municipal water for Jordan was not considered under Garfield Plan B, because of the obviously high cost of additional pumping and pipeline, which would be required.

Again, pertinent design data for the Garfield County Plan B system is given in Table V-E and corresponding detail is shown on the descriptive plates, which appear in the accompanying Detailed Map Assembly.

Garfield County Plan D

A low-lift pumping system, providing for water to be taken out of the Big Dry Arm of Fort Peck Reservoir, was suggested at the October 1, 1970, meeting in Circle. Garfield Plan D is the result of a study of this alternative. It would serve about 4,570 acres, at the lowest estimated per acre cost of the four Garfield plans discussed.

The Fort Peck Reservoir pumping plant would likely be located in Section 6, T20N, R43E, in McCone County and would consist of two 59 cfs pumps supported on an intake structure. No specific site was selected for the pumping plant in Garfield Plan D. Only one 300 foot (static head) lift is required for this system, with four miles of 42 inch pressure pipe. The pipe discharges into a canal, at about the middle of T20N, R42E, which then serves the lower portion of Woody Creek and meanders around ridges to Big Dry Creek at the R41E, R42E township line. No regulating reservoirs are proposed.

No possibility exists to provide a water supply for Jordan with Garfield Plan D.

Pertinent design information is provided in Table V-E. The location of the systems and the corresponding areas served are indicated, for each sub-area, on Garfield Plates 3, 4 and 5, which appear in the accompanying Detailed Map Assembly.

TABLE V-E

GARFIELD IRRIGATION SYSTEMS DATA SUMMARY

Item Description		Plan A	Plan B	Plan C	Plan D
Potential Acreage Served		21,360	9,770	17,650	4,570
Fort Peck Reservoir Pumping Plant Location		7-Blackfoot Creek Inlet Sec.1,T21N R33E	Hell Creek Sec29,T22N R38E	7-Blackfoot Creek Inlet Sec.1,T21N R33E	Big Dry Sec.6, T20N,R43E
PUMPING PLANT INFORMATION	Cfs,total	277	150	220	59
	Lifts	3	2	2	1
	Operating Pumps	5	2	4	1
	Standby Pumps	3	2	2	1
	Total hp	39,320	15,300	30,400	3,390
	Kwh/yr. (Millions)	139	36	108	9
	Static Head (Total)	900* 160	600	900	300
	Dynamic head (Total)	980* 175	720	950	380
	Pressure pipe length (mi.)	3.1* 1.5	6.5	3.1	4.0
	Pressure pipe size (in.)	72* 42	60	72	42
	Access roads (miles)	26	14	22	minimal
CANAL LENGTHS (miles)	200-300 cfs	13	0	13	0
	100-200 cfs	40	1	0	0
	50-100 cfs	51	80	61	15
	0-50 cfs	57	35	49	40
Stream Channel Used (miles)		210	64	180	30

*1st number refers to main lifts
2nd number refers to Woody Creek Repump Station

(continued on following page)

TABLE V-E (continued)

Item Description	Plan A	Plan B	Plan C	Plan D
Fencing miles	322	230	246	110
Canal & Pipeline R/W (miles)	164	122	126	60
Jordan Water Supply	yes	no	yes	no
Total Acre-Feet Pumped per Year	109,270	41,530	86,340	16,450
Estimated (acre-feet) Comsumptive Use	33,240	14,660	27,390	6,860
Reservoirs	a) 25 A.Ft. detention pond be- tween lifts b)20,000 A.Ft. on Smoky Butte Creek c) 6,000 A.Ft. on Wolf Creek d) 20 A.Ft. storage reservoir on Vail Creek for Jordan water supply	none	a) 20 A.Ft. detention pond be- tween lifts b)15,000 A.Ft. on Smoky Butte Creek c) 20 A.Ft. storage reservoir on Vail Creek for Jordan water supply	none

McCone County Plan A

This system corresponds with the desires of many persons in the Redwater River drainage, in that its primary objectives are to bring water to Circle and supply irrigation water along the Redwater River bottom land. It accomplishes more in terms of irrigation than just along the Redwater River, in that it supplies water for most of the creek channels on the west side of the drainage, between Horse Creek and Cow Creek. The water delivered into these Redwater tributaries serves additional land, with the excess flowing into the Redwater River.

With the pumping locations selected, the initial lift would suffice to serve the Prairie Elk Creek drainage. A minimum water supply of 600 acre-feet per month for a coal-steam electrical generating plant in the Weldon vicinity was also incorporated into the plan. This is particularly an important consideration, in view of the large quantity of electric power needed for the irrigation pumping, as well as the reported, present unavailability of the power needed. McCone County Plan A would provide irrigation water for 36,800 acres.

The proposed system, under McCone County Plan A, begins with a pumping plant on Fort Peck Reservoir in Section 21, T21N, R43E (McCone County Plates 5:3, 5:4 and 5:5 of the Detailed Map Assembly). The initial pumping plant would have to be supported over the lake, because of the range in reservoir elevation and the positive suction head required for high-lift pumping. Manufacturers of pumping equipment have estimated that the cost would be about the same, even if the static lift of about 325 feet were to be divided into two parts.

The initial pump capacity, under McCone Plan A, would be about 400 cubic feet per second, (cfs) or about 800 acre-feet per day. An 84-inch pressure pipeline, about 10,000 feet in length, would carry the water to a ridge, between Nelson Creek and McGuire Creek. A canal of 400 cfs capacity, and about 6.4 miles in length, would deliver the water to a reservoir, having an approximate capacity of 30,000 acre-feet. This reservoir, which would have to be constructed, would, in part, occupy a dry lake bed covering presently cultivated land. A canal of 500 cfs capacity, and 8.7 miles in length, would bring the water to a ponding area on a McGuire Creek tributary for relift over the drainage divide near the head of Horse Creek. A canal of about 120 cfs capacity, and 5.5 miles in length, would

begin near the ponding area and serve the Prairie Elk-McGuire irrigation and perhaps be used for the electric generation plant, which has been considered. The relift toward Horse Creek Divide would be about 320 feet, exclusive of the friction loss of about 65 feet. The 84-inch pipeline of about 3.5 miles in length, would have a capacity of 400 cfs. The water released to Horse Creek would pass through a chute spillway. Additional drops would be planned in the next few miles to prevent erosion. Lands along Horse Creek and downstream Redwater River would be served by this release. Storage of 10,000 acre-feet, preferably in the Horse Creek basin, would assist in supplying peak monthly use. About 16 miles of canal, with a peak capacity of 300 cfs, would bring water to the heads of Lost Creek and Cow Creek, from the end of the relift pipeline. A branch canal, approximately five miles in length, would bring water to the heads of Buffalo Creek and Duck Creek. The water released to Cow Creek, Buffalo Creek and Duck Creek would also serve the Redwater Valley, below the mouths of these creeks. Storage of an additional 10,000 acre-feet, somewhere in these creek basins, is also planned.

Some of the water released through Horse Creek would be rediverted, near Circle, into a canal about 30 miles long on the southeasterly side of the Redwater River. Its principal coverage would be about 11,000 acres in T21N, T22N and R50E. This canal, which should have a peak capacity of about 200 cfs, would end at Sullivan Creek.

The construction cost for McCone Plan A is estimated at $12,500,000. The principal physical features of the plan are given in Table V-F.

McCone County Plan B

McCone Plan B is a modification of Plan A and extends the northeast canal of Plan A to the headwater areas of Wolf Creek, Sheep Creek and Nickwall Creek an additional 106 canal miles. The extension would serve about 16,000 acres, primarily through delivery into the above three stream channels. The pumping equipment, pipe and canal sizes reaching back to the Nelson Creek pumping plant would be larger under Plan B, to accommodate the higher water demand. Without selecting any particular site, it was assumed that an additional 10,000 acre-feet of storage could be developed. The general plan is sufficiently flexible to make storage suitable on any of the streams used, other than Prairie Elk Creek or Sand Creek. Annual

industrial water use of 7,200 acre-feet for electric power generation, and municipal water for Circle would be provided as in McCone Plan A.

The construction cost for McCone County Plan A is estimated at $19,000,000. The principal features of the system are listed in Table V-F.

McCone County Plans Dismissed

Considerable thought was given, by the engineering research staff, to alternative systems which were dismissed, because of the relatively high cost of providing irrigation water. Two of these plans involved canals to increase the irrigable area served under Plan A in McCone County. One of the alternatives required an additional 50 miles of gravity canal, from the end of the pressure pipe at the Horse Creek divide, to reach the Redwater Creek Valley at Brockway. About 2,500 more acres would have been within reach of this extension Preliminary estimates of this extension indicated that the per acre costs would be somewhat higher, if this additional area were served, through extension of McCone Plans A and B. This may not, however, be the situation on the basis of a later detailed study.

Another trial involved increasing the size of the canal, which would divert water from the Redwater River, near Circle, under either McCone Plan A or McCone Plan B. Instead of ending at Sullivan Creek, a relift of about 140 feet, together with an additional 50 miles of canal, would bring the water to most of the Pasture Creek basin, lying north of the Circle-Richey road in Dawson County. The land area served by this extension would have included about 7,500 acres. The canal would have come within two and one-half miles of Richey A further lift of about 100 feet, non-irrigation season storage and two and one-half miles of pipeline would have been necessary to serve Richey. The construction cost of the additional system and the consequent enlargement of upstream works was approximated at $3,000,000 - about $400 per additional acre. This is about $50 more, per acre, than for McCone Plans A and B. The additional pumping at Sullivan Creek would cost about $2 per acre per year, assuming a three mill rate per kwh. Although this preliminary appraisal indicated a relatively higher per acre cost for this extension, more detailed study would be justifiable when more detailed maps are available. Preliminary field reconnaissance pointed to unusually rough terrain along Sullivan Creek and parts of Pasture Creek, indicating above average canal and structure

TABLE V-F

MCCONE IRRIGATION SYSTEMS DATA SUMMARY

Item Description		Plan A	Plan B
Potential Acreage Served		36,800	52,800
Location of Pumping Plant		Nelson Creek Arm Sec. 21, T21N, R43E	
PUMP	cfs,total	400	540
DATA	Lifts	2	2
Operating Pumps		6	8
Standby Pumps		2	2
Total Operating H.P.		42,000	58,000
KWH per Year (millions)		139	205
Total Static Head		640	640
Total Dynamic Head		740	746
Pressure Pipe Size		84"	90"
Pressure Pipe, Miles		5.4	5.4
Access Road, Miles		3.0	3.0
CANALS			
400-640 cfs		15	31
300-400		-	16
200-300		25	59
100-200		10	18
50-100		20	44
Stream Channels (miles)		160	260
Fencing (miles)		140	
R/W Miles of Right-of-way		75	175
Municipal Circle		a) yes	a) yes
Reservoirs Capacity in Acre-Feet		50,000	60,000
Industrial Electric Power		b) yes	b) yes
Pumpage	Average A.Ft. per Year	168,800	230,000
Usage	Consumptive Crop Use	55,100	79,000

a) Water delivery into Horse Creek

b) 500 MW plant using 7,200 acre-feet per year

costs. Additional water for use in coal development was not considered in the canal extension, although the plan could be so modified, if the need were to arise. The cost of bringing water, for municipal use, from the extension canal at Richey, appeared to be unjustifiable.

E. FORT PECK RESERVOIR PUMPING PLANS - COSTS

General Cost Criteria

In a preliminary feasibility study of this nature, cost estimates are necessarily approximate for two principal reasons. The first is that the lack of detailed topographic maps makes estimates of canal lengths, reservoir capacities, dam heights and other physical details, difficult and subject to later revision, assuming the development of better maps. The second reason is that the cost criteria used for the estimates can be, at this stage only approximate. For the high pump capacities and operating heads envisioned, costs are difficult to predict. Transportation costs and the lack of good native construction materials contribute to the uncertainty of assigning specific costs to various items. Brief discussions of the assigned construction costs follow.

Pumping Stations

Lump sum estimates, based on general experience, were used as cost estimates because of difficulties in estimating foundation requirements, structural system types and sizes, and other design features, of the proposed pumping stations. These estimates vary with the number and size of the pumps being used. Also, it is assumed that second-lift or re-pump stations on land will be considerably cheaper than those stations which will be at the lake side or supported over the lake.

Pump Costs

Pump, pump installation, and pump control costs used are subject to considerable variation because of a reluctance of manufacturers to devote great effort to providing precise cost data. Two general pumping concepts were considered. The first of these is to use a few custom-built, high capacity - high lift pumps. Information received from one manufacturer would give a cost of $650,000 for a 200 cfs pump, with a total design head of 360 feet. A 135 cfs pump for the same design head would cost $423,000. These cost estimates are for the delivered pump, but do not include installation. The alternate method, is to use several smaller, more standardized pump units to attain the desired capacity. Recent information

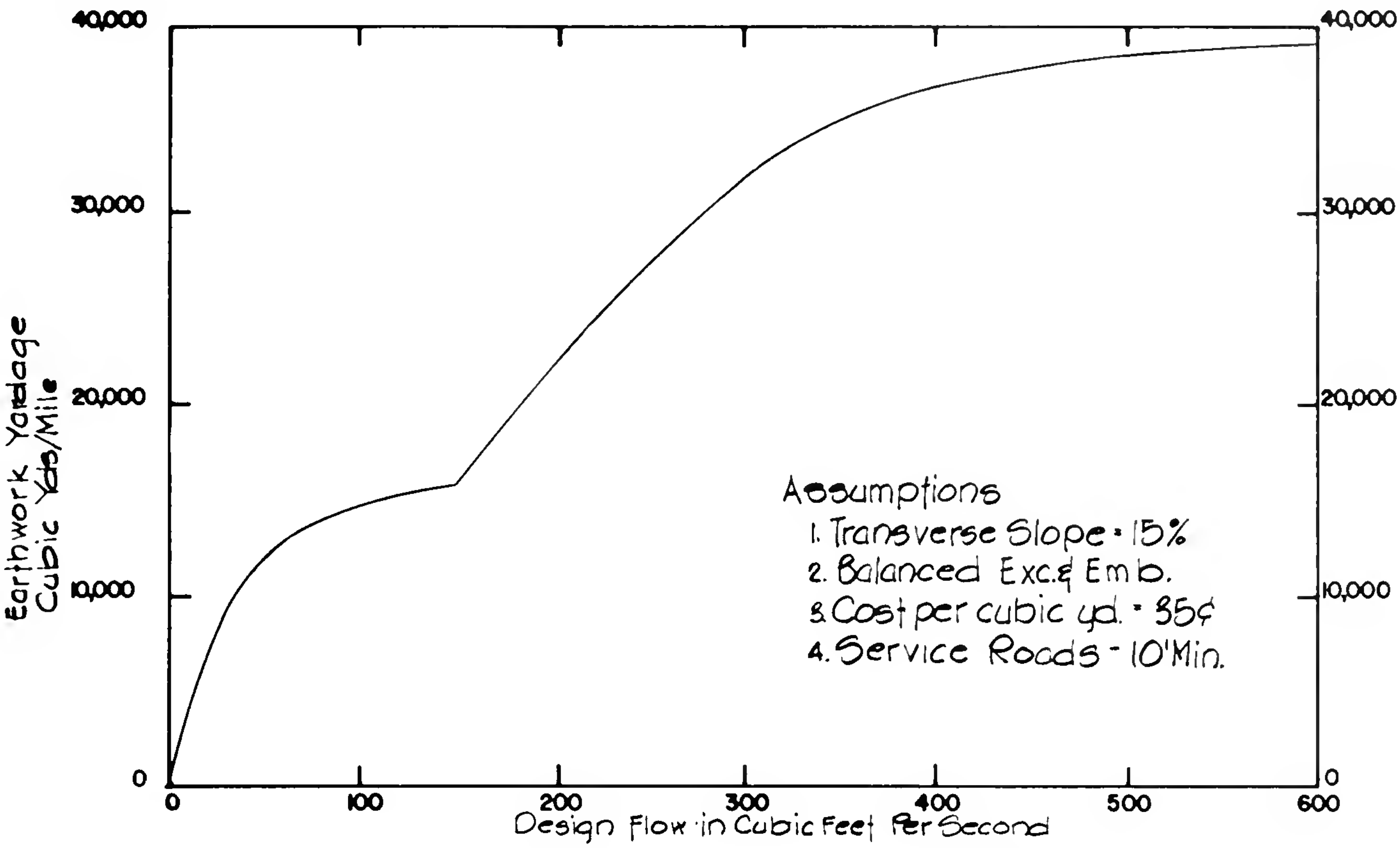
acquired from another manufacturer indicates that factory prices may range from \$38,000 for a 42 cfs pump, operating at a total design head of 300 feet, to \$51,000 for a 30 cfs pump, operating at 480 feet total design head. Some interpolation and judgment was needed to arrive at costs for each individual pumping site. About 10 percent of the base price was added to the plant or site costs to account for transportation and installation. Examination of low-head pumps for the initial lift from Fort Peck Reservoir, resulted in the conclusion that a minor saving would likely result from such implementation in certain of the plans. The price differential appeared not to be sufficiently large to warrant further consideration in this preliminary survey.

Pressure Pipe

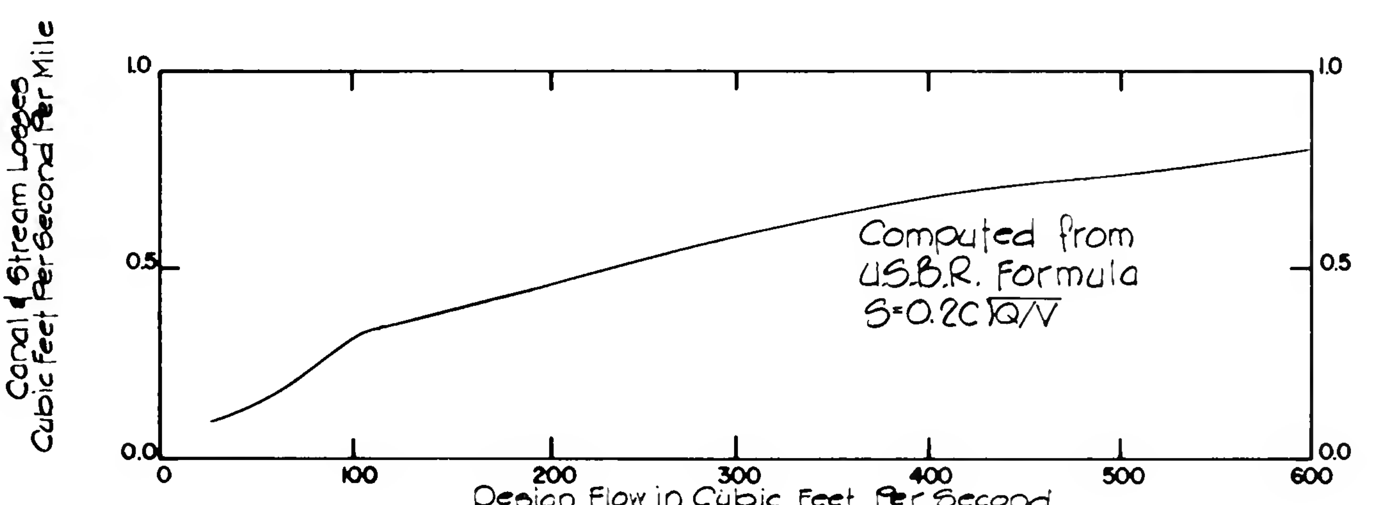
Concrete-lined, steel pressure pipe would be used for all pumping lifts and for outlet conduit from reservoirs. Installed costs of \$32/foot for 42 inch pipe, \$65/foot for 60 inch pipe, \$75/foot for 72 inch pipe, \$85/foot for 84 inch pipe and \$100/foot for 90 inch pipe were used for estimates. These prices were based on information of suppliers and downward scaling of actual bid prices for smaller quantities, as well as averaging the pressure requirements. The transportation of large diameter pipe is costly, therefore, the quantity of pipe required, it is judged, may justify a temporary manufacturing or assembly plant near the actual job site.

Canal Excavation

Canal excavation costs were estimated on the basis of Figure V-11(a). Canal sections were selected from the Bureau of Reclamation's *Design Manual #3*, concerning tabulation of recommended canal sizes and shapes (Figure 3A - Chapter I). Earthwork quantities for various capacities were then computed, using the assumptions shown in Figure V-11. The reverse bend in the curve, used in estimating earthwork quantities at a discharge capacity of 150 cfs, arose from the selection of canal shapes and discharge by fairly large increments in the design manual. The use of shapes, which would result in a smoother curve, would not have had a significant effect on the estimated earthwork quantities or cost of any of the plans. A cost of \$.35 per cubic yard was used for the cost estimates. Figure V-11(b) shows the canal losses used in the analyses. These were computed from the U.S. Bureau of Reclamation formula $S = 0.2C\sqrt{Q/V}$. The average "C" factor of 0.5, used for loss estimates, would be applicable to soil



a) Unlined Canal Yardage vs. Design Flow



b) Canal & Stream Losses vs. Design Flow

Figure V-11 : Earthwork Yardage & Canal Losses

textures about midway between clayey loam and sandy loam. Losses in stream channels were considered to be generally the same as for canals of equivalent flow. Reconnaissance, along the routes of the canals, indicated that the soils were dominantly clays of low permeability. Soil tests would be necessary to determine the justifiable need for canal linings. A reduction in canal losses, through membrane lining, would reduce pumping costs. This could more than offset the effect of increased construction cost on the annual costs. It was assumed that these two opposing factors would be sufficiently balanced to warrant dismissal in this preliminary survey of feasibility. Detailed study is, of course, necessary to determine the extent to which canal lining would be justifiable.

Canal Structures

It is anticipated that, on each canal, there will be structures ranging from flumes and tunnels, down to pumping checks. On the large 277 cfs canals for Garfield County Plans A and C, topographic features and slope limitations may require the use of considerable lengths of flumes or tunnels. These costs have been estimated at $30,000 per mile. At least some other smaller structures, such as bridges, stock underpasses, local drainage underpasses, wasteways or checks may well be required in each mile. A cost of $4,000 per mile has been assigned to these items for all sizes of canals. Separate lump sum estimates were made for canal diversions to stream channels, chutes, drops and other structures.

Stream Protection and Structures

Due to prolonged and increased flow in conveyance streams, additional fords and bridges were estimated to cost about $1,000 per mile. An additional $1,000 was used for bank stabilization and other minor erosion control.

Reservoirs

The cost estimates for reservoirs include all earthwork, riprap, spillways, intake structures, outlet works and diversion structures. Earthwork was estimated at $1.00 per cubic yard; rock riprap at $10 per cubic yard, and concrete at $150 per cubic yard. Reservoir locations tentatively selected or assumed to be available would have fairly small natural drainage areas to minimize spillway costs.

Fencing and Right of Way

The depth of water at capacity flow in most canals

indicated fencing both sides should be considered. In view of the large quantities involved a price of $.25 per lineal foot or $2,600 per mile was used. Right of way costs were averaged at $2,400 per mile for canals, $600 per mile for pipelines and $300 per acre for reservoirs, which would probably occupy areas having soil conditions of a satisfactory nature.

Access Roads

Roads needed in the vicinity of Fort Peck Reservoir were estimated at $20,000 per mile and $15,000 per mile in other areas.

Municipal Water Supply Systems

An approximate cost of supplying municipal water to Jordan was incorporated in Plans A and C for Garfield County. Plans A and B for McCone were based upon providing water in Horse Creek for Circle. The facilities necessary for additional storage, pumping and pipelines were not considered, as any estimate based upon present information may be more misleading than helpful. It was not considered feasible to bring Fort Peck Reservoir water to Richey. The potential dollar revenue to be realized from municipal water used by Jordan or Circle would certainly not be large enough to justify further consideration in this preliminary study.

Operation and Maintenance

It was assumed that the annual cost of parts and repair to the pumps and the pumphouse structure on Fort Peck Reservoir would be 2.5 percent of the initial construction costs. Labor for operating the entire system, including water regulation and collection of water revenue, was translated into man-years at $8,000 per man-year. Annual prorated costs for vehicles, construction equipment and materials were also assigned.

Pumping Power

Although this is essentially an operation and maintenance (O & M) cost, separate discussion of power costs is warranted, because of its major effect upon the annual cost of operation. Public electrical power in the Missouri River Basin is now committed to the extent of usual availability, according to an official of the U.S. Bureau of Reclamation. The same source stated that public electrical power has, in the past, been made available to pumping projects of the U.S. Bureau of Reclamation at two and one-half mills per

kilowatt hour. The electric power costs for the plans of this study were, however, based upon a rate of three mills per kilowatt hour. This, it should be noted, could be a very optimistic rate. A kilowatt hour rate of four mills, for example, would increase the estimated annual operating costs of McCone Plans A and B approximately $3 per irrigated acre. Due to higher lifts, a four mill rate would have a greater effect on cost incurred in Garfield Plans A, B and C. It is beyond the logical scope of this study to determine the cost of electrical power, since there are apparently no existing facilities to supply the quantity of power which would be required. Generation of power, through strip mining in the study area, may be the answer to relatively low cost power for the plans presented. No allowance was made in the construction cost estimates for transmission lines to serve the pumping plants, as the power source cannot be determined. A high voltage transmission line does, however,exist in the vicinity of Weldon.

Annual Costs

The annual cost estimates given are the composite of five main items: (1) retirement of initial construction cost over a 40 year period at 5½% interest; (2) annual electrical power cost; (3) pump repair and maintenance; (4) annual labor requirements; and (5) equipment use, canal and stream maintenance and accounting. A variation in interest rate or length of repayment period, it should be noted, would have considerable effect. The charge for electricity is another variable of major significance. The influence of each of these variables is examined in detail in Chapter VII. There has been no allowance made for interest cost during construction or the time lag which would exist between completion of project construction and full utilization of the construction. This cost variable is considered to be minor, however, in relationship to some of the other variables examined in Chapter VII.

Comments

The estimated costs of construction and O & M costs presented in this chapter are based upon water delivery in streams or main canals. Additional pumping or diversion from the streams or canals will be required for actual use. The lack of sufficiently detailed maps made it difficult to decide which of the lands, that were classified as potentially irrigable, should be considered to be within reach of the proposed alternate irrigation systems. Any material difference in acreage served will affect the estimated construction and operating costs. It must be recognized that this is a preliminary survey report and that the cost data which follow,

could upon further analysis, vary considerably. However, the data presented should definitely be adequate to form reliable judgments as to: (1) the desirability of detailed studies for certain works and (2) the dismissal of those works where costs are prohibitive or where public interest is currently lacking.

Alternate costs per acre, under the assumption that water could be sold to industrial users, such as a steam-electric power generation plant, were not considered in detail for the proposed Garfield systems, because of the area's relatively low potential for coal development. Such detail is, however, presented for the proposed McCone systems.

Appearing on pages 164 through 170 are construction cost summaries for each plan, including a tabular summary and annual cost by plan for Garfield and McCone Counties (Tables V-G and V-H).

(1) GARFIELD COUNTY PLAN A
CONSTRUCTION COST SUMMARY

1.	Pumping Stations and Pipe to Lift Over Divide	$ 5,939,000
2.	13.5 Miles 280 cfs Canal to Smoky Butte Reservoir	348,000
3.	Smoky Butte Reservoir and Outlet Works	3,205,000
4.	South Canal	607,000
5.	Smoky Butte Creek Diversion - 92 miles of stream	184,000
6.	East Canal to Wolf Creek Reservoir	1,111,000
7.	Jordan Water Supply	125,000
8.	Wolf Creek Storage Reservoir and Outlet Works	1,426,000
9.	Pumping Station and Pipe to Lift into Woody Creek	537,000
10.	Woody Creek Canal System	492,000
	BASE COST	$13,974,000
	Surveys, Engineering, Contingencies, and Construction Supervision @ 20%	2,795,000
	TOTAL	$16,769,000

(2) GARFIELD COUNTY PLAN B
CONSTRUCTION COST SUMMARY

1.	Pumping Stations and Pipe to Lift over Divide	$5,172,000
2.	Transition and Diversion Structures	92,000
3.	Woody Creek Diversion - 30 miles of stream	60,000
4.	West Canal	253,000
5.	Southwest Canal	1,378,000
6.	Big Dry Use - 34 miles	68,000
	BASE COST	$7,323,000
	Surveys, Engineering, Contingencies and Construction Supervision @ 20%	1,465,000
	TOTAL	$8,788,000

(3) GARFIELD COUNTY PLAN C
CONSTRUCTION COST SUMMARY

1.	Pumping Stations and Pipe to Lift over Divide	$ 4,997,000
2.	13.5 Miles 220 cfs Canal to Smoky Butte Reservoir	327,000
3.	Smoky Butte Reservoir and Outlet Works	2,754,000
4.	South Canal	607,000
5.	Smoky Butte Diversion - 92 miles of stream	184,000
6.	East Canal	1,191,000
	BASE COST	$10,060,000
	Surveys, Engineering, Contingencies and Construction Supervision @ 20%	2,012,000
	TOTAL	$12,072,000

(4) GARFIELD COUNTY PLAN D
CONSTRUCTION COST SUMMARY

1.	Pumping Stations and Pipe to lift to Canal	$1,216,000
2.	Transition and Diversion Structures	40,000
3.	15 miles - 59 cfs Canal	204,000
4.	40 miles - 34 cfs Canal	528,000
5.	30 miles Stream Use - Woody Creek & Big Dry	60,000
	BASE COST	$2,048,000
	Surveys, Engineering, Contingencies and Construction Supervision @ 20%	410,000
	TOTAL	$2,458,000

TABLE V-G
GARFIELD IRRIGATION SYSTEMS
SUMMARY AND ANNUAL COST BY PLAN

Item Description		Plan A	Plan B	Plan C	Plan D
Acreage Served		21,360	9,770	17,650	4,570
Total Construction Cost		$16,769,000	$8,788,000	$12,072,000	$2,458,000
Retirement of Construction Cost in 40 years @ 5½% interest		1,045,000	547,000	754,000	153,000
Annual Pumping Power Cost @ 3 mills		416,000	108,000	324,000	27,000
Annual Pump Maintenance Cost		97,000	57,000	74,000	14,000
Annual Labor Cost		40,000	32,000	32,000	16,000
Equipment Prorate, Canal & Stream Maintenance, Office					
TOTAL ANNUAL COST	Full User Financing	$ 1,643,000	$ 769,000	$ 1,219,000	$ 230,000
	50% User Financing	$ 1,121,000	$ 496,000	$ 842,000	$ 154,000
COST PER ACRE*	Full User Financing	$76.92	$78.71	$69.07	$50.33
	50% User Financing	$52.48	$50.77	$47.71	$33.70

*Assumes no water sale for power generation.

(1) MCCONE COUNTY PLAN A
CONSTRUCTION COST SUMMARY

1.	Pumping Plant and First Lift	$ 2,580,000
2.	6.4 miles 400 cfs Canal to Romine Reservoir	129,000
3.	Romine Reservoir	1,040,000
4.	8.7 miles 500 cfs Canal to McGuire Relift	200,000
5.	5.5 miles 120 cfs Canal to Weldon-Prairie Elk	78,000
6.	McGuire Regulating Reservoir	85,000
7.	McGuire Relift Pumping	3,450,000
8.	21 miles N.E. Canal	572,000
9.	Reservoirs in Cow Creek, Duck Creek or vicinity	750,000
10.	Horse Creek Conveyance and Storage	872,000
11.	30 miles South Canal	581,000
12.	70 miles Redwater River fords & etc.	70,000
	BASE COST	$10,407,000
	Surveys, Engineering, Construction Supervision and Contingencies @ 25%	2,080,000
	TOTAL	$12,487,000
	USE	$12,500,000

(2) MCCONE COUNTY PLAN B
CONSTRUCTION COST SUMMARY

1.	Nelson Creek Pumping and Pipe		$ 4,676,000
2.	Feeder Canal to Romine Reservoir (6.4 miles)		135,000
3.	Romine Reservoir (about 20,000 acre-feet)		1,040,000
4.	Canal to McGuire Relift (8.7 miles)		206,000
5.	Weldon - Prairie Elk Canal (5.5 miles)		78,000
6.	McGuire Regulating Reservoir		85,000
7.	McGuire Relift and Pipe		4,260,000
8.	Northeast Canals (106 miles)		1,756,000
9.	Erosion Control on Northeast (Wolf, Sheep, Nickwall)		198,000
10.	Reservoir Storage, Northeast Area		1,000,000
11.	Reservoir Storage in Cow and Duck Creeks		750,000
12.	Horse Creek Conveyance and Storage		872,000
13.	South Canal		581,000
14.	Redwater River Conveyance		70,000
		BASE COST	$15,707,000
	Engineering, Plans, Construction Supervision and Contingencies @ 20% at Basic Cost		3,141,000
		TOTAL	$18,849,000
		USE	$19,000,000

TABLE V-H
McCONE IRRIGATION SYSTEMS
SUMMARY AND ANNUAL COST BY PLAN

Item Description		Plan A	Plan B
Acreage Served		36,800	52,800
Total Construction Cost		$12,500,000	$19,000,000
Retirement of Construction Cost in 40 years @ 5½% Interest		779,000	1,184,000
Annual Pumping Power Cost @ 3 mills		417,000	615,000
Annual Pump Maintenance Cost		89,000	126,000
Annual Labor Cost		48,000	64,000
Equipment Prorate Canal & Stream Maintenance, Office		45,000	62,000
TOTAL ANNUAL COST	Full User Financing	$ 1,378,000	$ 2,051,000
	50% User Financing	$ 989,000	$ 1,459,000
COST PER ACRE*	Full User Financing	$37.45	$38.84
	50% User Financing	$26.88	$27.63

*Assumes no water sale for power generation.

Water Sale for Power Generation

The proposed plans acknowledge the fact that a 500 MW electrical generating plant may be built in the Weldon area, which would use about 600 acre-feet per month (7,200 acre-feet per year) in the conversion of strippable coal to electricity. The following tabular comparisons illustrate the resulting variations in the cost of water per acre irrigated, assuming: (1) various annual incomes from industrial sale of water and (2) that the construction costs are repaid by irrigation interests (Tables V-I, V-J, V-K and V-L). The examples are based upon retirement of the construction cost at 5½% interest over 40 years. No allowance has been made for a reserve or sinking fund to meet deficiencies in income. As indicated previously, neither has a provision been made for interest costs during construction and delays in achieving full income potential.

TABLE V-I

PER ACRE WATER COSTS WITH SELECTED
ASSUMPTIONS ON INDUSTRIAL USE*

MCCONE COUNTY PLAN A
With Full Repayment of Construction Costs by the User

Situation	Price for Industrial Water per Acre-Foot	Return from Industrial User	Return Required from Irrigation User		
			Total	Per Acre-foot	Per Acre Irrigated
a	--	--	$1,378,000	$8.03	$37.45
b	$50.00	$360,000	1,018,000	5.93	27.66
c	75.00	540,000	838,000	4.88	22.77
d	100.00	720,000	658,000	3.83	17.88

*Assumptions:

1. Full repayment of construction costs by the user.
2. Annual cost equals $1,378,000.
3. Annual income equals $1,378,000 for break-even situation.
4. 2.14 acre-feet of water required per irrigated acre and 4.663 total water required to supply the usable water of 2.14 acre-feet per acre.
5. Water Requirement situation a = o.
6. Water Requirement situations b, c and d = 7,200 acre-feet.
7. Irrigated acres equals 36,800.

TABLE V-J

PER ACRE WATER COSTS WITH SELECTED
ASSUMPTIONS ON INDUSTRIAL USE*

MCCONE COUNTY PLAN A
With 50 Percent Repayment of Construction Costs by the User

Situation	Price Industrial Water Per Acre-Foot	Return from Industrial User	Return Required for Irrigation User		
			Total	Per Acre-foot	Per Acre Irrigated
a	--	--	$989,000	$5.77	$26.88
b	$50.00	$360,000	629,000	3.67	17.09
c	75.00	540,000	449,000	2.62	12.20
d	100.00	720,000	269,000	1.57	7.31

*Assumptions:

1. 50 percent of construction costs by the user.
2. Annual cost equals $989,000.
3. Annual income equals $989,000 for break-even situation.
4. 2.14 acre-feet of water required per irrigated acre and 4.663 total water required to supply the usable water of 2.14 acre-feet per acre.
5. Water Requirement situation a = o.
6. Water Requirement situations b, c and d = 7,200 acre-feet.
7. Irrigated acres equals 36,800.

TABLE V-K

PER ACRE WATER COSTS WITH SELECTED
ASSUMPTIONS ON INDUSTRIAL USE*

MCCONE COUNTY PLAN B
With Full Repayment of Construction Costs by the User

Situation	Price for Industrial Water Per Acre-Foot	Return from Industrial User	Return Required from Irrigation User		
			Total	Per Acre-foot	Per Acre Irrigated
a	--	--	$2,051,000	$8.93	$38.84
b	$50.00	$360,000	1,691,000	7.36	32.03
c	75.00	540,000	1,511,000	6.58	28.62
d	100.00	720,000	1,331,000	5.79	25.21

*Assumptions:

1. Full repayment of construction costs by the user.
2. Annual cost equals $2,051,000.
3. Annual income equals $2,051,000 for break-even situation.
4. 2.14 acre-feet of water required per irrigated acre and 4.352 total water required to supply the usable water of 2.14 acre-feet per acre.
5. Water Requirement situation a = o.
6. Water Requirement situations b, c and d = 7,200 acre-feet.
7. Irrigated acres equals 52,800.

TABLE V-L

PER ACRE WATER COSTS WITH SELECTED
ASSUMPTIONS ON INDUSTRIAL USE*

MCCONE COUNTY PLAN B
With 50 Percent Repayment of Construction Costs by the User

Situation	Price for Industrial Water Per Acre-Foot	Return from Industrial User	Return Required from Irrigation User		
			Total	Per Acre-foot	Per Acre Irrigated
a	--	--	$1,459,000	$6.35	$27.63
b	$50.00	$360,000	1,099,000	4.78	20.81
c	75.00	540,000	919,000	4.00	17.40
d	100.00	720,000	739,000	3.22	14.00

*Assumptions:

1. 50 percent of repayment of construction costs by the user.
2. Annual cost equals $1,459,000.
3. Annual income equals $1,459,000 for break-even situation.
4. 2.14 acre-feet of water required per irrigated acre and 4.352 total water required to supply the usable water of 2.14 acre-feet per acre.
5. Water Requirement situation a = o.
6. Water Requirement situations b, c and d = 7,200 acre-feet.
7. Irrigated acres equals 52,800.

AREA BENEFITS - DIRECT AND INDIRECT

A. INTRODUCTION

Benefits derived from a specific water development project may be defined as "positive (beneficial) contributions toward the accomplishment of multiobjectives."[1] Such benefits may be either direct or indirect in nature and must be measured over time and oriented toward the achievement of stated objectives. In all cases, benefits may not be precisely quantifiable but may, instead require expression in qualitative terms. Expression of benefits in terms of dollars is desirable, unless other quantitative units are considered to be more appropriate.

In the case of the proposed East Central Water Conservancy District, the stated objectives are: (1) to affect more efficient use of the available land and water resources and (2) to stimulate and improve the area economy. The benefits which are measured in accordance with the stated objectives must also be compared to the cost of obtaining these benefits. Such a comparison, then, will provide a measure to make judgments as to the feasibility of a given project.

As indicated above such benefits may not always be of a direct nature. Not all of the identifiable benefits will be realized, within the area, in a direct fashion and may not, in fact, be realized for a number of years. Such a stimulating effect on developing areas is, in part, the result of the multiplier effect, which results when new spending, which is initiated, becomes income for others, thus providing new jobs and new opportunities. The overall affect of such activity is far more stimulating and widespread than would be anticipated on the basis of a cursory analysis.

Coal development in the Timber Creek-Weldon area near Circle may be used as an example. If such a development were to become a reality, one of the first implications would consist of additional employment and stimulated area trade. However as time progressed, benefits of a secondary or indirect nature would accrue to not only those directly

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[1] Source: *Standards for Planning Water and Land Resources July 1970*. United States Water Resources Council.

CHAPTER VI

AREA BENEFITS - DIRECT AND INDIRECT

involved in the original activity, but to those in the surrounding communities. Such indirect benefits would, for example, result from increased trade activity in the wholesale, retail and trade sectors, contributing toward general growth of those sectors, including larger volumes, improved service and product availability. From this example, then, it can be observed that benefits, at least in the long term, are substantially more far-reaching than would be anticipated from casual observation.

It is the objective of this chapter to outline in detail the types of benefits which would accrue from water development within the proposed Eastern Montana Water Conservancy District. The benefits which are discussed relate to: (1) potential coal development benefits, (2) agricultural irrigation benefits, (3) municipal water benefits and (4) other very important indirect benefits - particularly those affecting the socio-economic environment of the area.

B. COAL DEVELOPMENT BENEFITS

Anticipated Employment

The employment which could be anticipated as a result of coal development, within the proposed Conservancy District area, would depend largely upon the type of electrical power generation plant which was ultimately installed. This relative uncertainty is the result of changing technology within the electrical power generation industry. Chapter IV contains more detailed information on material relevant to this coal development question.

If, for example, a 500 MW generation plant were constructed within the next ten years, the plant would more than likely be of the conventional steam power generation type. It would employ from 35 to 45 individuals - 20 to 25 being employed in the generation plant itself, and 15 to 20 within the mining activity. If, however, such a generation plant became a reality sometime after the next ten years, 1980 or later, the general feeling is that the plant would be of the gasification-liquification type (M.H.D.). Such a power generation plant and its associated activities could employ as many as 15,000, of which about 500 would be engaged directly in the mining activity. The remaining employment for the area would be largely professional engineering, administrative and other highly trained technicians. The individual incomes, which would be anticipated in large part, would be relatively high,

particularly in comparison to the area's current average family income as described in Chapter II. A summary of the approximate employment, income and population derived under the two electric power generation systems appears on the following page:

TABLE VI-A

EMPLOYMENT, INCOME AND ESTIMATED POPULATION CHANGES RESULTING FROM INSTALLATION OF AN ELECTRIC POWER GENERATION PLANT IN THE WELDON-TIMBER CREEK AREA OF MCCONE COUNTY

	Generation Plant Type: Conventional Steam (500 MW)	Generation Plant Type: M.H.D. (1250 MW)[4]
Total Employment[1]	35 - 45	15,000
Mining	15 - 20	500
Plant	20 - 25	14,500
Total Income[2]	$317,500 - 407,500	$142,000,000
Mining	127,500 - 170,000	4,250,000
Plant	190,000 - 237,500	137,750,000
Total Population Increase[3]	105 - 135	45,000
Mining	45 - 60	1,500
Plant	60 - 75	43,500

[1]Employment data from Chapter IV. M.H.D. employment figures include refining, manufacturing and other associated activities.

[2]Income data from *Survey of Current Business*, July, 1970. Assumes average yearly incomes as follows: coal mining - $8,500, coal and petroleum products (engineers, technicians and administration - $9,500.) 1970 wage scales are used in all cases.

[3]Population attributable to coal development based upon average size family of three.

[4]Based on total of 1750 MW generation, with 1250 MW available for sale.

Agricultural and Municipal Water Inter-relationships

As indicated in Chapter V, the sale of water for industrial uses, such as electric power generation, has been considered Depending upon the type of generation plant which was ultimately installed, the demand in terms of acre-feet of water per year could be quite variable. Under the assumption that a conventional steam generation plant of the 500 MW size were developed within the next ten years, the demand in terms of acre-feet of water per year would be approximately 7,200 acre-feet. However, if a more expansive M H D plant were constructed beyond the next ten years, 1980 or later, the requirement in terms of water per year could be approximately 60,000 acre-feet. Needless to say, sale of such water for industrial uses, such as power generation, is an important, if not crucial, consideration to the development of the works considered under the proposed Eastern Montana Water Conservancy District. As indicated in Chapter V, per acre costs, even with the conventional steam power generation plant, would be substantially reduced by sale of water to such a user. If future technology indicates the feasibility of plants, such as the M.H.D. plant referred to previously, there is little doubt that the per acre costs for irrigation under the various proposed plans would be substantially and positively affected. The possibility of water sale to an industrial user most certainly initiates a favorable dimension to be examined in the analysis of proposed works feasibility.

C IRRIGATION BENEFITS

Introduction

There is little doubt that a major portion of the direct benefits, which would be attributable to water development in the study area, would involve direct benefits to agricultural water users. This is, certainly, not to say that there would not also be very significant direct and indirect benefits associated with water development in the areas of industrial, municipal and recreational water use. The area is now, however, totally dominated by agricultural economy In addition, it is certain that this area has a large number of resources, which are directly suitable to agricultural production, and that even with major industrial development, the area will remain as an important agricultural area. It is, therefore, assumed that the direct benefits from agricultural irrigation would be very significant as a result of increased water development in the area.

Management Assumption Concerning New Irrigated Lands

It is obvious from the material contained in this study that water development for irrigation purposes would require large sums of investment moneys, with the resulting cost of water to the individual farm user being relatively high compared to many other irrigation projects in Montana. Therefore, it has been assumed throughout this study that as additional water resources are developed, it will be a necessity to employ the very best in terms of management expertise at the farm level to make the most efficient use of the irrigation water made available through the new developments.

There is little doubt that, at the present time, the level of management employed on farms and ranches in Montana and in the study area varies significantly from farm to farm. The method of employing or using basic agricultural resources varies significantly among farms, as does the total productivity and return realized from the employment of these agricultural resources

Interviews with people of the study area, throughout the development of the research lead to the conclusion that the people of the area clearly recognize that top-level management is a prerequisite for successful and meaningful water development to take place for irrigation purposes in the study area. This is brought about, primarily, because of the fact that water developments, such as those being considered in the study area, are costly and the water will be relatively expensive by the time it is made available on the individual farms and ranches. This demands that the best possible use be made of the water on the individual farms or ranches involved.

A cursory examination of individual farm and ranch situations, or an analysis of agricultural statistics, clearly reveals that management levels do vary significantly from farm to farm. The assumption made in this study in terms of all judgments made, as to preliminary feasibility of water development, definitely assumes the employment of top-level management. The study, however, does not attempt to in any way identify a present-day, typical, or average situation. It can basically be assumed that, if a historically typical or average situation prevails, water development projects would become less feasible than under the assumption of top-level management. Meetings and interviews conducted with individuals of the study area, as mentioned previously, clearly revealed to the research staff that the necessity

of this assumption is clearly recognized within the study area itself.

The Anticipated Use of New Irrigated Acres

It is impossible to talk about the direct benefits of bringing new irrigated acres into production, unless the likely uses which will be made of this new irrigated land have been discussed. It is assumed in this analysis that the major portion of new irrigated acres in the study area would initially be used for the growing of crops to directly support increased livestock production within the area. It is also recognized that certain smaller acreages would be used for the production of cash grains and other specialty crops.

The use of the new irrigated acres would tend to vary significantly as certain variables change which are not necessarily controlled or even affected by actions within the area, that reflect overall changes in the total agricultural economy of the nation. Thus, in no way is the thesis being advanced that livestock support crops would be the only use, or for that matter, even the major long-term use, of new irrigated acres The assumption is made, however, that a high probability exists that the major portion of new irrigated acres would initially go into the production of crops which would be used directly in the support of livestock. This thesis has been strongly supported by interviews with individuals in the study area conducted by the research staff as the study progressed.

New Irrigated Acres and Existing Farm Units

The study and analysis of the location of the potentially irrigable lands within the study area as presented in Chapter III and the Detailed Map Assembly, clearly shows that these acreages are not heavily concentrated in a few isolated areas These potentially irrigable lands are scattered throughout the entire study area, and the only large concentration of such lands lies along the Redwater River drainage in the eastern portion of McCone County and the western portions of Dawson and Richland Counties. Even along this drainage, the lands are quite scattered, in that there are no high concentrations of potentially irrigable land in contiguous areas.

It was, thus, assumed that the overwhelming majority of new irrigated lands, as identified within the study area, would be added to existing farm and ranch units rather than

going into or making up new, self-contained irrigated farms. This assumption has been strongly supported by conversations and interviews with local people in the area as to their beliefs concerning the likely use of new irrigated acres.

Again, it is clearly recognized that not all of the new irrigable land would be added to existing units, but it is assumed that the majority of it would, in fact, fall into that category of use Very little of the new irrigated land in this study area would go entirely into new farm units, such as has been the case on many irrigation projects in Montana

Livestock Feeds and Potentially Irrigable Lands

One basic question that must be asked in an analysis of benefits attributable to irrigation of potentially irrigable lands, relates to the identification of the types of crops which would likely be raised on the new irrigated lands. This is a very complicated and complex question, especially in light of the fact that this decision will be made primarily by existing, individual farm managers who will be adding irrigated acres to their already existing resource base.

The factors that will be most instrumental in determining how the new irrigated lands are used, are factors which are uniquely peculiar to the individual farm or ranch situation or resources to which the irrigated land base would be added.

The two most critical factors which would determine how new irrigated lands would be used on an individual farm or ranch situation are linked directly to: (1) the management employed on that farm or ranch and (2) the identification of the total resources which are available for use in an individual farm or ranch situation

One example is that a particular farm or ranch may have a set of resources, which obviously results in a situation where the ranch has a deficient supply of winter feed. This may result simply because the present resources do not allow for the production of sufficient winter feed to balance with other resources available during other periods of the year.

Yet a second individual ranch situation might have an excess capacity of fall and winter feed production, while at the same time experiencing a critical shortage of summer feed Examples of this are relatively easy to find within the study area, because of the large acreages of small

grains produced. These small grains produce or result in some production of fall and winter feed in the form of straw as a by-product of the grain production, as well as animal unit months (AUM's) of fall grazing on acreages of harvested grain crops and range lands which are intermittent with these acreages of cash grains. In this second ranch situation, the most efficient use of the irrigated acres would likely dictate a much different use than in the first situation discussed

Yet a third possibility would be to have a farm-ranch combination with an abundance of low-quality winter feed roughage in the form of straw, with no adequate way of using this straw because of insufficient availability of the kinds of feeds which can be fed in combination with straw in wintering livestock This farm unit would likely use the potentially irrigable acres in yet another fashion.

The point being made in the above paragraphs is simply that the individual farm or ranch situation will ultimately dictate the use of the new irrigated acres. This would not, however, be the case if an examination were made of irrigation projects where it was assumed that new, self-contained irrigated farms would result. No attempt has been made, in this study, to identify the exact use to which new irrigated acreages will be put, other than to specify that they will be added to existing units. In addition, they will likely go into the production of feeds to directly support livestock. No attempt is made in this preliminary study to estimate the proportion of the new irrigated acreages that would go into any one of these livestock supporting feeds.

The sections which follow describe four possible uses of new irrigated land. Specific crops are used only to indicate the expected productivity of these crops on the new irrigated acres in the area, assuming top-level management in the employment of all resources relative to these new irrigated lands The crops that will be discussed are:

1. Winter feed in the form of high quality hay;
2. Improved irrigated pasture which is intensively managed;
3. Corn and other silage;
4. Small grains to be used in the area as livestock concentrates.

Benefits From Crops Grown on New Irrigated Acres

It is possible to outline, for any specific crop, an expected cost of production and compare that to its expected

gross return. As a result, it is possible to derive a net gross return as a result of producing this crop. In other words, it is possible to outline for a particular crop a series of management practices associated with the growing of that crop and directly compare that to the yield and price associated with the output.

Such an example is found in Table VI-B for one particular crop; namely, alfalfa hay. The material found in that table is based or obtained directly from material published in Bulletin 1069 of the Montana Cooperative Extension Service. This data shows estimated annual stand establishment costs of $8.50 per acre per year for alfalfa hay. This amount is estimated to be the share, on a per year basis, which should be attributable to an acre of alfalfa hay for the re-establishment of that crop on a regular basis. In addition, there are other direct operating costs of $6.45 per acre, excluding harvesting (Table VI-B). Also, the table shows direct harvesting costs of $23.44 per acre, which assumes three crops of hay harvested per year. This results in a sub-total of $38.39 in direct operating costs, with a total direct cost of the production of an acre of alfalfa being $48.91 when other overhead and management costs are included. This does not include any cost which might be directly associated with the land or irrigation water itself. Land costs in this instance were estimated at $34.29, resulting in a total cost of $83.20.

Many precautions are found in the forward of Bulletin 1069 which caution the reader in the use of the contained data for any purpose other than as a guideline to an average situation, given very specific assumptions concerning farm organization and size These precautions are well taken, because it is quite simple to abuse this type of data, even though it is very useful for its designed purposes.

It is possible to compare this cost data, for example, to a yield of alfalfa hay of (x) tons per acre, at a value of (y) dollars per ton, available on the farm or ranch. This means that the gross return from the production of a four-ton alfalfa hay crop, valued at $25 per ton, would be approximately $100. Annual operating costs would be $48.91, giving a gross return of $51.09 to cover all land and water costs, plus return to the operation in question. If the land costs are separated out, this leaves a return of $16.80 to cover direct water costs, plus a dollar return to the operation. This is one method of identifying the benefit which would be attributable to the increased production of alfalfa hay, as a result of the new irrigable land in the study area.

This is, however, a type of analysis which is extremely dangerous without complete knowledge about the individual farm or ranch situations involved. This type of analysis is not employed in this study for a number of reasons.

First, the yield assumption of four tons of irrigated alfalfa per acre varies among farms and ranches. There are many farms and ranches within Montana, in established irrigated areas where the yields of alfalfa hay on irrigated lands are from two to three tons per acre. It is obvious that a yield of from two to three tons per acre can be achieved in individual situations with considerably less cost than is included in the example described above. One reason for lower costs results because the handling costs are certainly less when lower tonnages are involved.

In addition, considerable variations also exist in individual cost items, as reflected in detailed studies of individual farms or ranches, and as pointed out in the Bulletin 1069 itself.

It is entirely possible that on some farms and ranches the costs of handling the hay crop may vary considerably because of management and associated factors. An example is that handling costs per acre often decrease as the tonnage per acre produced increases. It is also certain that the relevant question to ask in terms of an individual farm situation is not the question as outlined above, but rather, what does the result look like as one adds new irrigated acres in the production of alfalfa hay to an existing ranch situation This total effect can never be identified by the kind of analysis employed above.

Discussions with agricultural leaders in the study area resulted in assumptions that, under top-level management conditions and adequate supplies of irrigation water throughout the production year, six to eight-ton alfalfa hay yields could be obtained. This, of course, again assumes a maximum utilization of resources and full employment of the agricultural technology available to individual operators.

Thus, the approach to benefits, which could be derived from the production of individual crops within the study area, is discussed in non-monetary terms in this preliminary feasibility study. A clear recognition exists that these benefits, on an individual farm or ranch situation can be identified if, and only if, very specific assumptions are made as to the use of the new irrigated acres.

Problems with livestock supporting crops such as corn silage and irrigated pasture are even more difficult to deal with in the fashion described above. The problem of pricing the AUM's of grazing produced or the tons of corn silage produced, further complicates matters, because these crops do not have well established market prices. Assumptions of \$3.50 or \$4.00 per AUM of grazing on irrigated pasture can be made, but, at best, this would be only a guess. There is not a well established market for the products of such grazing practices.

TABLE VI-B

ALFALFA HAY - COSTS PER ACRE*

Operation	Total Cost per Acre
Cleaning ditch	$ .70
Weavil control, custom	4.00
Irrigate	1.75
Mowing	5.42
Raking	5.72
Baling	7.96
Twine	1.82
Hauling & stacking labor	.70
Truck and loader	1.82
Annual cost of stand establishment	8.50
Subtotals	38.39
Interest on operating capital	.60
Miscellaneous overhead, 5% of subtotal	1.92
Management, 10% of 4 tons @$20	8.00
	$48.91

REAL ESTATE COSTS PER ACRE

Item	Total Cost per Acre
Land	$28.38
Building & improvements	5.91
Subtotals	34.29
Total Cost Per Acre	$83.20

*Source: *Enterprise Costs of Irrigated Crops in South Central Montana*, Cooperative Extension Service, Bulletin 1069, November, 1969, Montana State University, Bozeman.

Irrigated Pasture Benefits

It is quite probable that a portion of the new irrigated acres would go into the production of irrigated pasture to be used as a summer feed for livestock. This land use shift would provide several types of very significant benefits to individual farm and ranch operations.

The first and most obvious benefit would be that the new irrigated acre would provide a significantly larger number of AUM's of feed than if the land were used as a dry crop acre or an acre in dryland range. It would be assumed that under top-level management, 10 to 15 AUM's of grazing per season per acre could be obtained by carefully managed irrigated pasture.

In addition, the increased carrying capacity of the ranch acreages of irrigated pasture would allow for a considerably different use of dryland range than is now common on most ranches in the study area. Much of the dryland range in the study area is currently being grazed during the early spring and summer periods when the range crops are in their growth process and struggling to maintain themselves on the range. It is considered very beneficial to the dryland range resources if grazing can be deferred entirely or made very light during the early spring and mid-summer periods to allow for a steady, undisturbed growth of the native range lands. Such practices are highly recommended to improve native range and increase the carrying capacity. However, such practices are now very costly, and in some cases, totally impractical because of the conditions under which the typical study area ranch operates. However, if large acreages of irrigated pasture were available to use during this period, it would be possible to defer use of the dryland range resources during the early spring and mid-summer periods and use irrigated pasture in its place. This would allow fuller utilization of the feed produced on the range by deferring its use to periods during the late summer, fall, and winter. During these periods, range plants are dormant in terms of major growth activity. This late fall and early winter use of dryland range would also, in some instances, result in improved ability to substitute relatively inexpensive AUM's of winter grazing on the deferred range for AUM's now being supplied by relatively more expensive winter hay or silage feeding programs.

Thus, it is again quite obvious that in this type of situation, one acre of irrigated pasture would result in a benefit to the individual farm or ranch situation, of

significantly more than just the equivalent "market value" of the 10 to 15 AUM's of feed produced. Such practices would insure better utilization of all resources, including the existing dryland range resources.

Alfalfa Hay and Corn Silage

Certain farm and ranch units within the study area are now either limited severely in terms of their ability to produce winter feeds or are forced to produce this winter feed in a very inefficient manner. In many cases, winter feed is currently being produced by harvesting hay or silage of relatively low yield over a large number of acres. These hay acreages are, largely, either in dryland hay or wild hay, which is harvested in valleys, because water spreading practices occur in these valleys.

In addition, there exists a number of acres, both of domestic and wild hay, where minimum irrigation has been employed through the development of on-farm resources or water spreading systems, which distribute water onto these lands and thereby increase hay production.

The addition of new irrigated acres on such farm units would allow for a much more concentrated production of the winter feed and, at the same time, free existing acres for other uses such as grazing. Many acreages now used for the production of wild hay would be very desirable for complementary use with other native range resources. This concentration of hay production on fewer acres tends to reduce the time and certainly the cost of producing hay on the individual farm units.

This increased ability to produce on-farm winter feed in the form of high-quality hay or silage would, in many instances, make it more feasible for an individual farm or ranch operation to more adequately use the straw which is produced as a by-product of cash grains grown on dryland crop acres. A considerable amount of straw is available for winter feed and could be used as a relatively cheap roughage. Much of the straw currently available is not being fully utilized. Part of the reason for this poor utilization of low-quality roughage is undoubtedly tied to the lack of other on-farm feeds, having sufficient quality and produced at prices or costs which will make them available to feed in combination with straw. An example would be that the production of large quantities of high-quality alfalfa hay or corn silage at reasonable costs could provide an opportunity for more effective utilization of low-quality

roughages, such as wheat and barley straw, which are now by-products of cash crops grown on certain farms in the area.

Under top-level management, it is estimated that 20-28 tons of corn silage and 5 to 7 tons of alfalfa could be realized on the new irrigated acres. Use of this feed production would open up several new alternatives to the management and use of resources available on individual area farms and ranches.

Cash Grains and Other Crops Grown as Concentrates for Livestock Production

Certain irrigated acres made available to individual farms or ranches will be used for the production of concentrate feeds in the form of silage or grains to be used in the feeding of livestock This will allow for individual farm-ranch situations to produce some of their own supplement feeds, not only for the wintering of breeding stock, but also for the wintering and/or fattening of calves produced on the farm. These concentrate feeds could be used in a variety of ways. The precise usage would depend entirely upon the existing individual situation in terms of resources available to the farm or ranch.

It is entirely conceivable that large numbers of calves which are currently sold from the farms in the area could be held over and sold as yearlings or as fattened animals. This is one likely result of making increased irrigated lands available to the area. Throughout the development of this study, it has become obvious that there is considerable interest in additional cattle feeding within the study area. If this desire becomes a reality, significant acreages of feed grains could be produced on new irrigated lands to directly support such livestock feeding operations.

It should again be pointed out that even without livestock feeding, some acreages used for production of concentrate feeds will likely be used to support breeding herds and other livestock produced on the farm.

Other Direct Benefits from New Irrigated Acres

It has been stated above that new irrigated acres could result in many direct benefits to individual farmers and ranchers. Such benefits would include summer feed, winter feed, and/or concentrate feeds produced on farms as a result of making water available to the area's lands. Additional significant benefits of a direct nature would also

result from this new irrigation activity and new irrigated lands, not only within the farm unit, but also in the entire area. Increased agricultural employment would undoubtedly result on the individual farms and ranches, as well as a significant increase in total income and resource use flexibility upon individual farms and ranches.

There would also be a significant increase in the tax base, including the value of agricultural properties, as a result of the introduction of acreages of new irrigated lands into the area. Increased stabilization of the agricultural economy would result in many other indirect benefits affecting the area's total socio-economic environment.

These indirect benefits are discussed in some detail in Part E of the current chapter as they relate to not only agricultural development, but also water development for industrial, municipal, and recreational purposes.

Potentially Irrigable Lands of the Study Area

Details concerning the identification of potentially irrigable lands and the acreages of such lands are found in Chapter III of this report. Additionally, in Chapter III, there is a series of enumerative data tables containing material relevant to: (1) total crop land by township, (2) total potentially irrigable land by township, (3) potentially irrigable land by class, and (4) the acreages of range and crop land which would be replaced by the potentially irrigable lands which have been identified. As pointed out in Chapter III, all of these potentially irrigable lands are certainly not within reach of the proposed works, which are outlined and discussed in detail in Chapter V. These lands, it should be noted, were delineated as potentially irrigable lands in the absence of any detailed consideration concerning the ultimate feasibility of securing irrigation water for the lands in question.

Chapter V contains detailed engineering data relating to the acreages and locations of the potentially irrigable lands which could be reached by each of the six alternate irrigation systems considered. Following, in this chapter is a set of tables which summarize all of the material presented as to potentially irrigable lands in Chapter III, as well as information concerning the lands which would be reached under each of the alternate irrigation systems.

Tables VI-C, VI-D, and VI-E summarize all of the material presented in Chapter III as to potentially irrigable lands in each of the 28 sub-areas of the study area. The detailed tables for each sub-area, as well as the descriptive plates, show the location of all potentially irrigable lands (Chapter III).

Table VI-C shows that there are total potentially irrigable lands in Garfield County of 50,946 acres. Of this 50,946 acres, Table VI-C indicates that 34,826 acres of the land is classified as Class III and 16,120 acres as Class II. In addition, it is also shown in Table VI-C that nearly 75 percent or approximately 38,000 acres of the potentially irrigable land area is now in range land, with the other 25 percent or 13,000 acres presently being used as cropland. Approximately 32 percent of potentially irrigable land is classified as Class II.

Table VI-D shows that there are 97,668 acres of potentially irrigable land identified in McCone County. This 97,668 acres of potentially irrigable land includes 26,926 acres in Class II and 70,742 acres in Class III. The present use of the potentially irrigable lands in McCone County includes approximately 62 percent which is now crop, with 37 percent presently in range.

The data in Table VI-E shows that the areas of potentially irrigable land in Dawson and Richland Counties which are included in this study account for 82,784 acres. The majority of these acres, or 57 percent, are now in cropland, with 43 percent in rangeland. The potentially irrigable land in Dawson and Richland Counties is broken down between classes as follows: Class II - 27 percent; Class III - 73 percent.

A quick review of Tables VI-C, VI-D, and VI-E, which is a summary of material presented in Chapter III, clearly reveals that there is a large number of acres of potentially irrigable lands scattered throughout the study area. Exact locations of these lands are, of course, identified in detail in Chapter III and the Detailed Map Assembly. There would indeed be a tremendous benefit derived by the individual farms within the study area, as well as to the economy of the entire proposed conservancy district area, should these potentially irrigable lands

TABLE VI-C
POTENTIALLY IRRIGABLE LAND IN
GARFIELD COUNTY BY STUDY SUB-AREA

Study Sub area	Potentially Irrigable Land (Acres) Present Use: Cropland - red Rangeland - green Class II	Class III	Total
G-1	-	-	-
G-2	-	-	-
G-3	-	-	-
G-4	1275	395	1670
	238	92	330
	1037	303	1340
G-5	214	2413	2627
	-	40	40
	214	2373	2587
G-6	3875	8566	12441
	1864	2323	4187
	2011	6243	8254
G-7	4438	8133	12571
	919	1337	2256
	3519	6796	10315
G-8	221	1350	1571
	120	198	318
	101	1152	1253
G-9	1344	1958	3302
	125	499	624
	1219	1459	2678
G-10	1341	1354	2695
	366	219	585
	975	1135	2110

(continued on following page)

	Class II	Class III	Total
G-11	2194 1113 1081	3407 1228 2179	5601 [illegible] 3260
G-12	312 23 289	2092 245 1847	2404 [illegible] 2136
G-13	687 – 687	686 – 686	1373 – 1373
G-14	219 147 72	4472 1885 2587	4691 [illegible] 2659
GARFIELD TOTALS	16,120 4,915 11,205	34,826 8,066 26,760	50,946 12,981 37,965
Percent by Class Percent Cropland Percent Rangeland	31.64 30.49 69.51	68.36 23.16 76.84	100 25.48 74.52

TABLE VI-D
POTENTIALLY IRRIGABLE LAND IN
MCCONE COUNTY BY STUDY SUB-AREA

Study Sub area	Potentially Irrigable Land (Acres) Present Use: Cropland - red, Rangeland - green Class II	Class III	Total
M-1	5383	4990	10373
	3518	1557	5075
	1865	3433	5298
M-2	4595	28918	33513
	2513	20002	22515
	2082	8916	10998
M-3	1152	2162	3314
	486	1038	1524
	666	1124	1790
M-4	1021	11440	12461
	423	8338	8761
	598	3102	3700
M-5	2724	2196	4920
	2067	1363	3430
	657	833	1490
M-6	717	3281	3998
	572	1893	2465
	145	1388	1533
M-7	1428	1264	2692
	465	545	1010
	963	719	1682
M-8	2076	5755	7831
	1118	3105	4223
	958	2650	3608
M-9	3258	6604	9862
	2215	4513	6728
	1043	2091	3134

(continued on following page)

	Class II	Class III	Total
M-10	4572 [illegible] 2080	4132 [illegible] 1531	8704 [illegible] 3611
MCCONE TOTALS	26,926 15,869 11,057	70,742 [illegible] 25,787	97,668 [illegible] 36,844
Percent by Class Percent Cropland Percent Rangeland	27.57 [illegible] 41.06	72.43 [illegible] 36.45	100 62.28 37.72

TABLE VI-E
POTENTIALLY IRRIGABLE LAND IN
DAWSON AND RICHLAND COUNTIES BY STUDY SUB-AREA

Study Sub area	Potentially Irrigable Land (Acres) Present Use: Cropland - red, Rangeland - green Class II	Class III	Total
DR-1	-	1213	1213
		1148	1148
		65	65
DR-2	1642	7036	8678
	936	5397	6333
	706	1639	2345
DR-3	17069	36419	53488
	7534	23338	30872
	9535	13081	22616
DR-4	3272	16133	19405
	1363	7481	8844
	1909	8652	10561
DAWSON, RICHLAND TOTALS	21,983	60,801	82,784
	9,833	37,364	47,197
	12,150	23,437	35,587
Percent by Class	26.55	73.45	100
Percent Cropland	44.73	61.45	57.01
Percent Rangeland	55.27	38.55	42.99

be shifted from their present use and developed as irrigated lands.

Gross Return Variances Between Rangeland or Dry Cropland and Fully Developed Irrigated Acres

An acre of land which is presently in the production of native range can generally be assumed to yield approximately one-half animal unit month (AUM) of grazing per year. This yield does vary somewhat, depending upon the quality of the rangeland acre in question. Generally, however, one quarter to three quarters of an AUM per acre is the production which could be expected annually from an acre of rangeland. Assuming a value per AUM of grazing of $4.50 per acre, this would indicate that the annual gross return from an acre of rangeland would vary from a low of under $2.00 per acre to a high of slightly more than $3.00 per acre. Thus, the logical conclusion is that the gross return from one acre of rangeland would be expected to be between $2.00 and $3.00 per acre.

Substantial acreages of the cropland in the study area are presently used in the production of cash grains, primarily wheat. Most of this dryland cash grain farming centers around a crop harvested every two years, with summer fallow on that acreage in the alternate year. The expected wheat yield from an acre of cropland in the study area could generally be assumed to be between 25 and 35 bushels. If it were then assumed that $1.50 per bushel is the expected price for wheat, it would be concluded that the gross return per harvested acre of cropland would be between $37.50 and $52.50. It is necessary to divide this return in half to account for the fact that one acre is expected to be harvested every other year--yielding an expected annual gross return from cropland of approximately $19 to $26 per acre.

Under the assumptions which have been described in the above two paragraphs and earlier sections of this chapter, it is clear that the addition of irrigable acres to existing farm units can be expected to contribute more in terms of gross benefit to that farm unit than just the value of the crop produced on any individual acre. This conclusion has been established on the basis that the relevant consideration to be examined in relationship to total benefits is not only the cash return per individual acre added, but rather the cash return received, plus the overall contribution that the addition of an irrigable acre makes to the total farming operation and total resource use.

It is possible, in a rough way, to estimate the expected gross return or production which would be attributable to new irrigable acres used in the production of various crops. For this analysis, it was assumed that an acre of irrigated alfalfa hay could be expected to produce from four to six tons of hay per acre. With hay valued at $25 per ton, this would account for an annual expected gross return of $100 to $150 per acre.

The expected gross return from irrigated pasture would be $45 to $75 per acre per year. This return was based on the assumption of 10 to 15 AUM's of production per year, valued at $4.50 per AUM.

Irrigated barley was assumed to yield 70 to 100 bushels per acre, with barley valued at $.85 per bushel. This would yield a gross return of $60 to $85 per acre per year.

A crop of corn silage yielding 20 to 25 tons would produce an annual crop return of $140 to $175. This return assumes a price of $7 per ton of corn silage.

From the discussion above, it is obvious that when an acre of dry cropland is replaced by a fully developed acre of irrigated land, the expected gross return from the new irrigated acre could be logically expected to increase by three to eight times its original return as dry cropland. This means simply that when an acre of dry cropland is replaced with an acre of fully developed irrigated land, the gross income effect to the area and to the farm in question is tremendous. This does not, however, tell the entire story in that the addition of this irrigated acre will likely make a much larger contribution to the individual farm or ranch than just the estimated cash return in production from that acre, because of an improved ability to manage the total resource base.

The multiplying effects are much greater, however, when one considers the conversion of an acre of rangeland to an acre of fully developed irrigated land. In this instance, the increase in gross income or return would be 40 to 60 times that experienced from dryland range.

From the above discussion, it is obvious that the development of potentially irrigable lands within the study area would have significant direct income effects, not only for the individual farms involved, but for the entire study area. It is also clear from Chapter III that large acreages of potentially irrigable land are available for such water development.

Potentially Irrigable Lands Reached By Each Alternate Irrigation System Analyzed

Chapter V considers six alternate irrigation systems; four of which are in Garfield County and two of which are in the area of McCone, Dawson, and Richland Counties.

The following series of tables (Tables VI-F, VI-G, VI-H, VI-I, VI-J, and VI-K) summarize the data for each of these plans, as to the total potentially irrigable land which could be developed under each plan. This data is presented by township and includes the following information: (1) the total potentially irrigable land by class and in total for each township under the plan and (2) the acreage of potentially irrigable land which, if developed, would replace existing cropland or rangeland by township and land class.

Table VI-F shows the potentially irrigable land by township under Garfield Plan A described in detail in Chapter V. This plan covers a total of approximately 21,360 acres. Approximately 28 percent or 6,000 acres of the 21,360 is currently in the production of crops with 72 percent or 15,000 presently in the production of dryland range. The data in Table VI-F shows that 61.5 percent of the land classified as potentially irrigable is in Class III, with 38.5 percent in Class II.

Table VI-G contains detailed data as to potentially irrigable land under Garfield Plan B, which includes a total acreage of approximately 10,000 acres. Over 80 percent of the acreage covered or classified as potentially irrigable land is now in dryland range. Also, 80 percent of the land classified as potentially irrigable land is in Class III.

Table VI-H presents details as to potentially irrigable lands covered under Garfield Plan C, while Table VI-I includes the same information for Garfield Plan D. The data for Garfield Plan C, about 17,700 acres, reveals that approximately 31 percent of the total land classified as potentially irrigable is in Class II, with approximately 69 percent being Class III. Again, it is interesting to note that the majority of the land--nearly 70 percent--is presently in range land. Garfield Plan D includes approximately 4,600 potentially irrigable acres, with 80 percent being presently used as rangeland. This potentially irrigable land is again predominantly Class III, with approximately 82 percent being in that category.

TABLE VI-F
GARFIELD PLAN A

POTENTIALLY IRRIGABLE LAND REACHED (ACRES)

Legal Description	Present Use: Class II	Cropland - red Rangeland - green Class III	Total
T17N - R35E	299	64	363
	288	29	317
T18N - R35E	222	810	1032
	82	573	655
T18N - R36E	40	901	941
	40	745	785
T19N - R35E	915	1149	2064
	417	534	951
T20N - R35E	363	23	386
	70	21	91
T18N - R37E	837	-	837
	784	784	784
T18N - R38E	11	717	728
	11	660	671
T18N - R39E	-	850	850
	-	748	748
T18N - R40E	555	378	933
	308	282	590
T18N - R41E	144	466	610
	121	424	545

(continued on following page)

	Class II	Class III	Total
T18N - R42E	-	200	200
	-	10	10
	-	190	190
T19N - R36E	613	1290	1903
	485	245	730
	128	1045	1173
T19N - R42E	-	2477	2477
	-	739	739
	-	1738	1738
T20N - R42E	-	707	707
	-	20	20
	-	687	687
T19N - R39E	491	498	989
	204	59	263
	287	439	726
T19N - R40E	277	200	477
	5	57	62
	272	143	415
T20N - R39E	874	-	874
	216	-	216
	658	-	658
T19N - R38E	37	464	501
	11	144	155
	26	320	346
T19N - R37E	147	800	947
	92	392	484
	55	408	463
T20N - R36E	152	178	330
	132	66	198
	20	112	132
T20N - R40E	616	43	659
	25	-	25
	591	43	634
T20N - R41E	1086	712	1798
	195	60	255
	891	652	1543

(continued on following page)

	Class II	Class III	Total
T21N - R40E	540	210	750
	[illegible]	—	[illegible]
	330	210	540
TOTALS	8,219	13,137	21,356
	[illegible]	[illegible]	[illegible]
	5,379	10,003	15,382
Percent by Class	38.49	61.51	100
Percent Cropland	[illegible]	[illegible]	[illegible]
Percent Rangeland	64.45	76.14	72.03

TABLE VI-G
GARFIELD PLAN B

POTENTIALLY IRRIGABLE LAND REACHED (ACRES)

Legal Description	Present Use: Cropland - red Rangeland - green Class II	Class III	Total
T19N - R39E	45	45	90
	19	5	24
	26	40	66
T20N - R39E	150	-	150
	38	-	38
	112	-	112
T21N - R39E	667	143	810
	2	80	82
	665	63	728
T18N - R40E	555	378	933
	247	96	343
	308	282	590
T19N - R40E	277	200	477
	5	57	62
	272	143	415
T20N - R40E	616	43	659
	25	-	25
	591	43	634
T21N - R40E	608	238	846
	236	-	236
	372	238	610
T18N - R41E	144	466	610
	23	42	65
	121	424	545
T20N - R40E	1086	712	1798
	195	60	255
	891	652	1543

(continued on following page)

	Class II	Class III	Total
T18N - R42E	-	200	200
	-	10	10
	-	190	190
T19N - R42E	-	2477	2477
	-	739	739
	-	1738	1738
T20N - R42E	-	707	707
	-	20	20
	-	687	687
TOTALS	4,148	5,609	9,757
	790	1,109	1,899
	3,358	4,500	7,858
Percent by Class	42.51	57.49	100
Percent Cropland	19.05	19.77	19.46
Percent Rangeland	80.95	80.23	80.54

TABLE VI-H
GARFIELD PLAN C

POTENTIALLY IRRIGABLE LAND REACHED (ACRES)

Legal Description	Present Use: Cropland - red, Rangeland - green Class II	Class III	Total
T17N - R35E	299	64	363
	11	35	46
	288	29	317
T18N - R35E	222	810	1032
	140	237	377
	82	573	655
T18N - R36E	40	901	941
	-	156	156
	40	745	785
T19N - R35E	915	1149	2064
	498	615	1113
	417	534	951
T20N - R35E	363	23	386
	293	2	295
	70	21	91
T18N - R37E	837	-	837
	53	-	53
	784	-	784
T18N - R38E	11	717	728
	-	57	57
	11	660	671
T18N - R39E	-	850	850
	-	102	102
	-	748	748
T18N - R40E	555	378	933
	247	96	343
	308	282	590

(continued on following page)

	Class II	Class III	Total
T18N- R41E	144	466	610
	23	42	65
	121	424	545
T18N - R42E	-	200	200
	-	10	10
	-	190	190
T19N - R36E	613	1290	1903
	485	245	730
	128	1045	1173
T19N - R42E	-	2477	2477
	-	739	739
	-	1738	1738
T20N - R42E	-	707	707
	-	20	20
	-	687	687
T19N - R39E	491	498	989
	204	59	263
	287	439	726
T19N - R40E	277	200	477
	5	57	62
	272	143	415
T20N - R39E	370	-	370
	93	-	93
	277	-	277
T19N - R30E	37	464	501
	11	144	155
	26	320	346
T19N - R37E	147	800	947
	92	392	484
	55	408	463
T20N - R36E	152	178	330
	132	66	198
	20	112	132
TOTALS	5,473	12,172	17,645
	2,287	3,074	5,361
	3,186	9,098	12,284
Percent by Class	31.02	68.98	100
Percent Cropland	[illegible]	25.25	30.38
Percent Rangeland	58.21	74.75	69.62

TABLE VI-I
GARFIELD PLAN D

POTENTIALLY IRRIGABLE LAND REACHED (ACRES)

Legal Description	Potentially Irrigable Land (Acres) Present Use: Cropland - red Rangeland - green Class II	Class III	Total
T19N - R42E	- - -	2477 739 1738	2477 739 1738
T20N - R42E	- - -	707 20 687	707 20 687
T20N - R41E	828 149 679	552 44 508	1380 193 1187
TOTALS	828 149 679	3,736 803 2,933	4,564 952 3,612
Percent by Class Percent Cropland Percent Rangeland	18.14 18.0 82.0	81.86 21.49 78.51	100 20.86 79.14

TABLE VI-J
MCCONE PLAN A

POTENTIALLY IRRIGABLE LAND REACHED (ACRES)

Legal Description	Potentially Irrigable Land (Acres) Present Use: Cropland - red Rangeland - green Class II	Class III	Total
T21N - R44E	-	400	400
	-	112	112
	-	288	288
T21N - R45E	182	1218	1400
	141	937	1078
	41	281	322
T22N - R45E	1440	60	1500
	1151	49	1200
	289	11	300
T25N - R45E	-	800	800
	-	328	328
	-	472	472
T20N - R46E	246	354	600
	170	190	360
	76	164	240
T21N - R46E	102	98	200
	59	35	94
	43	63	106
T22N - R46E	225	75	300
	146	37	183
	79	38	117
T23N - R46E	204	196	400
	107	117	224
	97	79	176
T24N - R46E	48	203	251
	12	174	186
	36	29	65
T20N - R47E	654	57	711
	244	19	263
	410	38	448

(continued on following page)

	Class II	Class III	Total
T22N - R47E	398	576	974
	358	[illegible]	[illegible]
	40	139	179
T19N - R48E	270	1230	1500
	174	[illegible]	[illegible]
	96	549	645
T20N - R48E	153	747	900
	85	[illegible]	[illegible]
	68	247	315
T21N - R48E	-	500	500
	-	310	[illegible]
	-	190	190
T22N - R48E	-	500	500
	-	180	[illegible]
	-	320	320
T20N - R49E	-	500	500
	-	165	165
	-	335	335
T22N - R49E	-	700	700
	-	448	448
	-	252	252
T24N - R50E	275	2225	2500
	74	1626	1700
	201	599	800
T25N - R50E	-	2464	2464
	-	1552	1552
	-	912	912
T26N - R50E	150	2350	2500
	24	1826	1850
	126	524	650
T27N - R50E	370	130	500
	185	80	265
	185	50	235
T20N - R50E	88	312	400
	30	98	128
	58	214	272
T21N - R50E	2700	2300	5000
	1029	1521	2550
	1671	779	2450

(continued on following page)

	Class II	Class III	Total
T22N - R50E	2450 253 2197	4550 1567 2983	7000 1820 5180
T23N - R50E	1118 512 606	3182 2670 512	4300 3182 1118
TOTALS	11,073 4,754 6,319	25,727 15,659 10,068	36,800 20,413 16,387
Percent by Class Percent Cropland Percent Rangeland	30.09 42.93 57.07	69.91 60.87 39.13	100 55.47 44.53

TABLE VI-K
MCCONE PLAN B

POTENTIALLY IRRIGABLE LAND REACHED (ACRES)

Legal Description	Potentially Irrigable Land (Acres) Present Use: Cropland - red Rangeland - green		
	Class II	Class III	Total
T21N - R44E	- - -	400 112 288	400 112 288
T21N - R45E	182 141 41	1218 937 281	1400 1078 322
T22N - R45E	1440 1151 289	60 49 11	1500 1200 300
T25N - R45E	- - -	800 328 472	800 328 472
T20N - R46E	246 170 76	354 190 164	600 360 240
T21N - R46E	102 59 43	98 35 63	200 94 106
T22N - R46E	225 146 79	75 37 38	300 183 117
T23N - R46E	204 107 97	196 117 79	400 224 176
T24N - R46E	48 12 36	203 174 29	251 186 65
T20N - R47E	654 244 410	57 19 38	711 263 448

(continued on following page)

	Class II	Class III	Total
T22N - R47E	398	576	974
	358	437	795
	40	139	179
T23N - R47E	-	532	532
	-	358	358
	-	174	174
T24N - R47E	201	289	490
	121	183	304
	80	106	186
T25N - R47E	-	450	450
	-	159	159
	-	291	291
T26N - R47E	110	390	500
	50	295	345
	60	95	155
T19N - R48E	270	1230	1500
	174	681	855
	96	549	645
T20N - R48E	153	747	900
	85	500	585
	68	247	315
T21N - R48E	-	500	500
	-	310	310
	-	190	190
T22N - R48E	-	500	500
	-	180	180
	-	320	320
T23N - R48E	75	2425	2500
	45	1880	1925
	30	545	575
T24N - R48E	101	529	630
	32	207	239
	69	322	391
T25N - R48E	-	50	50
	-	42	42
	-	8	8
T26N - R48E	-	2100	2100
	-	1764	1764
	-	336	336

(continued on following page)

	Class II	Class III	Total
T20N - R49E	- - -	500 165 335	500 [illegible] 335
T22N - R49E	- - -	700 [illegible] 252	700 [illegible] 252
T24N - R49E	- - -	2712 2045 667	2712 2045 667
T25N - R49E	- - -	1350 1094 256	1350 1094 256
T26N - R49E	- - -	3000 1740 1260	3000 [illegible] 1260
T27N - R49E	30 18 12	170 138 32	200 156 44
T24N - R50E	385 104 281	3115 2276 839	3500 2380 1120
T25N - R50E	- - -	2950 1848 1102	2950 1848 1102
T26N - R50E	150 24 126	2350 1826 524	2500 1850 650
T27N - R50E	370 185 185	130 80 50	500 265 235
<u>DAWSON COUNTY</u>			
T20N- R50E	88 30 58	312 98 214	400 [illegible] 272
T21N - R50E	2700 1029 1671	2300 1521 779	5000 [illegible] 2450
T22N - R50E	2450 253 2197	4550 1567 2983	7000 1820 5180

(continued on following page)

	Class II	Class III	Total
T23N - R50E	1118	3182	4300
	512	2670	3182
	606	512	1118
TOTALS	11,700	41,100	52,800
	[illegible]	26,510	31,560
	6,650	14,590	21,240
Percent by Class	22.16	77.84	100
Percent Cropland	43.16	56.84	59.77
Percent Rangeland	64.5	35.5	40.23

In consideration of the direct benefits which are attributable to any of the plans discussed for Garfield County, direct reference should be made to the details included in Table VI-F, Garfield Plan A; Table VI-G, Garfield Plan B; Table VI-H, Garfield Plan C; and Table VI-I, Garfield Plan D.

Detailed tables are also contained on the pages following for McCone Plan A, Table VI-J and McCone Plan B, Table VI-K.

The total acreage included under McCone Plan A, as described in detail in Chapter V, is 36,800 acres. Plan B contains all of Plan A, plus additional extensions. The total land covered under McCone Plan B is 52,800 acres. The detailed data by township for McCone Plans A and B reveal that for both plans, slightly more than one-half or approximately 55 to 60 percent of the land which is currently classified as potentially irrigable is now in cropland, with 40 to 45 percent in rangeland.

The land classified as potentially irrigable under Plan A in McCone County consists of approximately 30 percent Class II and 70 percent Class III land.

The additional lands added to McCone Plan A to comprise McCone Plan B, alters this percentage to 22 percent of the total land in Class II and 78 percent in Class III.

All discussions relating to the secondary or indirect benefits discussed in Section F of this chapter, draw heavily upon the data discussed and presented here in relationship to potentially irrigable lands. Chapter VII presents an assessment as to preliminary feasibility of the individual plans, as described in Chapter V and summarizes the acreages of land which could be developed under each plan.

Conclusions on Agricultural Benefits

From the above discussion, it is clear that the direct benefits to existing agricultural units within the study area could be very significant as a result of incorporation of new irrigated lands into those existing units. As stated previously, all judgments as to feasibility of water development in this study are based on the assumptions that (1) new irrigated lands would be added onto existing farm units and (2) new irrigated land would experience the application of top-level management and technology. In addition, most of the new irrigated lands would go initially into the production of crops in direct support of the livestock enterprise.

No attempt has been made to estimate the expected costs and expected returns from the incorporation of such new irrigated lands, because of the extreme variability that would be associated with their use from farm to farm. It is, however, definitely concluded that very significant benefits would be derived by the individual farm or ranch units which would be involved in the corporation of such lands. The productivity of these properties and the benefits (direct and indirect) which result would be such that if, on a preliminary feasibility basis, it is shown that water could be delivered to the farm at a cost of from 10 to 20 dollars per acre per year, then the proposed water development studied here should definitely be pursued in detail in order to test feasibility with a more adequate and complete knowledge

D. MUNICIPAL WATER BENEFITS

As described in Chapter III, the current municipal water situation within the east central Montana study area leaves much to be desired. The benefits which could be realized from an improved water supply should be examined both in terms of water quality and water quantity.

Information from Mueller Engineering of Billings was obtained in relationship to their State contract for city water engineering. Mueller's study is not an in-depth study for individual communities, and therefore, national trends were used for individual city water use projections. For example, average daily consumption for a city was estimated by assuming 200 gallons average consumption per person per day. Total daily consumption was then arrived at in each case by multiplying by the appropriate historical or projected population This method, according to Mueller, yields data which represents an ideal water supply situation and is not necessarily intended to correspond perfectly with present felt needs of the area users. The works and systems which have been proposed in Chapter V of this preliminary study do not in any case provide a municipal water supply delivered to the city limits; however, in some cases a viable supply of water would be available within reach of existing municipal water systems.

In terms of water quality, there is little doubt that an alternate source of municipal water; in particular, the Jordan and Circle areas, would be desirable. Benefits accruing, however, from improved water quality are vague and difficult to quantify.

In terms of water quantity demanded, information is available for the cities of Jordan in Garfield County; Circle, Vida, and Brockway in McCone County; and Richey in Dawson County. Conclusions of the Mueller study were that of the cities indicated above, all but Brockway and Vida have needs for increased future water supplies. Although Jordan's population is projected to decrease between 1970 and 1990, recommendations have been made for one additional well, which would provide 135 gallons per minute (gpm). Current average daily consumption of municipal water in the Jordan community is approximately 111,000 gallons.

Circle's population is projected to increase between 1970 and 1990, with an accompanying increase in demand from their municipal water supply. Average daily consumption in the Circle community is anticipated to increase from the present 230,000 gallons to 280,000 gallons in 1990. Recommendations have been made that the Circle community provide for an additional 510 gallons per minute (gpm), which would create 680 gallons per minute (gpm) instantaneous capacity.

The community of Richey in Dawson County is projected to increase in population between 1970 and 1990, with an accompanying increase in average daily consumption of municipal water from 95,000 gallons per day in 1970 to approximately 106,000 gallons in 1990. Recommendations have been made to establish an additional 180 gallons per minute (gpm) capacity, which would create a total instantaneous capacity of 260 gallons per minute (gpm).

There is little doubt that, within the proposed East Central Montana Water Conservancy District, the need for an improved municipal water supply exists. In view of the fact that the present water supply is limited to wells yielding water high in total solids, it has been advised that alternate sources of municipal water be examined and pursued to provide for future needs. It would be desirable for the new source of municipal water supply to be adequate both in terms of quality of water and quantity of water.

Monetary benefits derived from municipal water users could be realized to assist in subsidizing irrigation costs within the study area. The amount of such payments, however, would no doubt be quite minimal in comparison to the total cost of the systems contemplated.

E. RECREATIONAL BENEFITS

Introduction

The recreational benefits which would likely accrue to those within the study area as a result of water development stem from three major changes. These changes within the area include: (1) improvement of live streams within the area by addition of Fort Peck water, (2) construction of regulating and holding reservoirs within the study area, (3) construction of distribution canals. It is believed that as a result of these improvements, additional recreational benefits in terms of fishing, hunting, boating, camping, and picnicing will be available to area residents.

In general, it is believed that a fishing lake should be of at least twenty acres in size to consider its value in terms of recreational benefits. Also, a lake for fishing purposes should be at least fifteen feet deep over at least 25 percent of the lake's total area. Such rules of thumb are based primarily upon the effects of weather conditions such as snow and ice during the winter, as well as evaporation during dry periods. Availability of a constant water supply such as a canal, could easily alter the above rules of thumb.

In terms of waterfowl development, 160 acres including water, dikes, and supporting fields to provide feed is considered to be the minimum size practical. Some waterfowl development will, no doubt, result from the availability of additional canals within the study area.

In addition to the improvement of fishing and hunting, it is believed that additional opportunities in terms of camping, picnicing, and boating would be available.

Garfield Plans

In terms of recreational potential, Garfield Plan A provides for a regulating or storage reservoir of 20,000 acre-feet at the head of Smoky Butte Creek. An additional 6,000 acre-foot storage reservoir on Wolf Creek also is provided for in Plan A. Garfield Plans B and D provide no possibility in terms of regulating or storage reservoirs. Garfield Plan C provides recreational potential in terms of one 15,000 acre-foot regulating reservoir at the head of Smoky Butte Creek, but does not provide a second storage reservoir at Wolf Creek as does Plan A. The following area streams would be affected by the addition of water to

live streams: Lone Tree Creek, Smoky Butte Creek, Steve's Fork of the Big Dry, Big Dry Creek, Vail Creek, Frasier Creek, Woody Creek and Wolf Creek The length of existing stream channels used in the various plans are Plan A - 210 miles, Plan B - 64 miles, Plan C - 180 miles, and Plan D - 30 miles

The length of canals included in the various plans are: Plan A - 161 miles, Plan B - 116 miles, Plan C - 123 miles, and Plan D - 55 miles

McCone Plans

In terms of regulating or storage reservoir recreational potential, Plan A for McCone provides one 50,000 acre-foot reservoir and Plan B provides one 60,000 acre-foot reservoir. Live stream recreational improvement, as a result of increased quantities of water, include such streams as Horse Creek, Middle and East Fork of Prairie Elk Creek, Lost Creek, Duck Creek, Cow Creek, Wolf Creek, Sheep Creek, Nickwall Creek, as well as the Redwater River. Existing lengths of the stream channels used in the McCone plans are: Plan A - 160 miles, Plan B - 260 miles Recreational benefits, particularly in terms of hunting and fishing, result from 70 miles of canal in Plan A and 168 miles of canal in Plan B.

Summary

It is believed that a great number of recreational benefits may accrue to area residents as a result of the contemplated water development within the study area. Benefits in terms of improved fishing, hunting, boating, camping, and picnicing are no doubt an important part of these benefits. Accurate assessment of these benefits, however, is a difficult task and definitely merits additional detailed study

F THE MULTIPLYING OR ECONOMIC EXPANSION EFFECTS OF DIRECT BENEFITS ASSOCIATED WITH WATER DEVELOPMENT - INDIRECT BENEFITS

It should be clear from the above discussions in this chapter that water development projects, such as the one being considered in the feasibility of the establishment of a conservancy district in east central Montana, would result in significant direct benefits. These can be categorized as direct benefits associated with water development in relationship to agricultural, industrial,

municipal, and recreational uses. There are certainly large measures of direct benefits derived from each of the water uses associated with development in the area.

It has been pointed out above that by converting the use of an acre from rangeland to irrigated land, gross income from that acre would increase from 40 to 60 times, while the conversion of an acre from dryland cropland to irrigated land would increase direct gross income from three to five times. In addition, it has also been pointed out above that there are numerous other direct benefits associated with the addition of irrigated acres to an existing farm unit. Such addition of irrigated acres affords the farm unit an opportunity to more efficiently utilize its total resources.

It has also been stressed that significant recreational benefits would be associated with water development in the area. These recreational benefits would, in fact, assist in increasing the general level of activity in the area and would be accompanied by an overall increase in spending.

Considerable discussion contained in earlier sections of this report revealed that water development in the area could induce and promote significant industrial development by utilizing the area's vast coal resources.

The development of such industrial activity would directly create income and jobs in the area which are presently not available. Earlier discussions have also centered on the improvement of municipal water supplies, in terms of both quantity and quality, which could be associated with development of water for beneficial use within the study area.

All of the direct income benefits, which are attributable to various uses of water developed within the area, would have multiplying income effects throughout the study area. A clear example of this is that as an acre of land becomes developed as an irrigated acre, significantly more inputs must be purchased or used on that land to induce the expected productivity. The expanded use of purchased inputs would, of course, expand directly the trade activity within the area. This activity would create additional employment opportunities for human resources in direct relationship to the agricultural development. There are definitely multiplying effects associated with either employment or income increases, because of the very simple fact that one person's expenditures do, in reality, become another person's

income. As one receives additional income, part of that income is spent and part of it is saved. The part of the increased income that is spent again becomes income to someone else--thus, the multiplying effects throughout an area economy as a result of expanding a specific economic sector. The total effect on aggregate income within the study area would be several times greater than the direct effect which would be associated with the income increase.

It is obvious that all of the developments described above would tend to increase or stabilize the population and employment of the area. The agricultural activity, as well as the industrial activity which could be associated with development, would create jobs and employment for people in the area. Chapter II clearly reveals that the area is declining in terms of employment and population and that water development projects, such as the one examined here, would tend to stabilize or increase population, as well as stabilize employment and increase the number of job opportunities available in the area.

There is little doubt that this type of increased economic activity would have a significant effect upon the entire socio-economic climate of the area. A tendency would exist for more services to be available within the area, as well as more retail and wholesale-type activity. This growth again creates more jobs.

The tax base of the area would be significantly affected by large-scale water development projects. New industrial plants and facilities could contribute directly to tax base. The construction of works to deliver the water to the various sections of the area would also create construction jobs, operation and maintenance jobs, and also contribute to expansion of the tax base.

In addition, it can be assumed that the market value of an acre of rangeland presently within the study area is approximately $20 to $40, while the present value of an acre of dryland cropland is from $75 to $100. It is fair to say that acres, which would be changed from their present use and developed as irrigated acres, would expand the per acre value of such property to from $300 to $400--an expansion of the existing tax base on these acreages by several multiples.

In conclusion, many indirect benefits would be associated with water development such as that examined in this study. These indirect benefits are of major importance and

should be examined in clear and specific detail in any detailed feasibility study. Such benefits are certainly, however, recognized as exerting an extremely positive effect.

PRELIMINARY ANALYSIS OF PROPOSED SYSTEMS FEASIBILITY

A. IDENTIFICATION OF IMPORTANT COST VARIABLES TO ASSESSING FEASIBILITY

Introduction

The assessment or judgment as to preliminary feasibility, as called for in the conducting of this study, falls into two specific categories, as clearly spelled out in Chapter I of this report.

One key question that needs to be answered, as stated in Chapter I, is as follows: "Test, on a preliminary feasibility basis, the desirability or likely potential feasibility of works contemplated within the proposed conservancy district. In this study, these works are primarily centered on the question of distributing water from Fort Peck Reservoir into part or all of the study area to be put to beneficial uses in the area."

The details in terms of the systems which have been considered, as well as detailed engineering material relating to costs of such systems, are spelled out in Chapter V of this report. The result of this entire work is represented by an estimate, as to the annual cost of water per acre of irrigated land. This cost per acre assumes that the water is delivered to the individual farm units, or potentially irrigable acres and acknowledges the various required systems.

The research contained in this preliminary feasibility study started from the very beginning, in terms of conceiving the alternate systems, as well as the identification and location of potentially irrigable lands in the study area. Chapter V, as stated previously, presents the works involved in the various systems and states the acreages of land which would be potentially irrigable under each system. The graphic results of this research phase are shown in the Detailed Map Assembly, which supplements this report.

Engineering Cost Variables in Assessing Feasibility

It is obvious that a preliminary feasibility study involving the design of systems, such as those presented in Chapter V, necessarily requires that many estimates be made as to the costs which would be associated with the various plans in question. Chapter V clearly spells out many of the

assumptions and problems that are associated with the costing out of various segments of the systems.

All of the proposed systems involve significant costs, which can be associated with the pumping of water from Fort Peck Reservoir to higher elevations for distribution within the study area. It is extremely difficult to precisely identify the costs which would ultimately be associated with such pumping operations because of the very specialized types of equipment involved. Much of this specialized equipment is either market price or would be specially designed by an individual manufacturer for the specific purpose intended. It is, thus, extremely difficult to pinpoint precisely the costs which would be associated with such equipment.

It is also certain that the various alternate plans presented would require extremely large quantities of specialized equipment, not only in terms of pumps, but pressure pipeline and other specialized items in relationship to the pumping plants involved. This necessarily causes cost estimation problems, because of the large quantity of such equipment which is required, as well as the complexity of the equipment design.

Another extremely complex item to estimate is the cost per kilowatt-hour of electrical power to be used in the pumping of water for these systems. Extremely large quantities of power would be required in nearly all of the systems, as examined in Chapter V. The assumption made in terms of power cost is, indeed, a critical assumption to assessment of ultimate feasibility for the various systems. The power costs account for a major portion of the operation and maintenance (O & M) cost associated with the water delivery systems. It is possible that power could be supplied through Corps of Engineers or through power generated in the area as a result of electrical generation plants using coal resources. Such power may be available at significantly less cost than has been assumed in this study. This is, however, a critical assumption for which it is extremely difficult to pinpoint precise data at this time.

Another very critical assumption, which had to be made in terms of the engineering data assembled for each alternate plan, involved estimation of the canal lengths necessary to transport water from one point to another, within the study area. It is obvious to those acquainted with the area, that the existing terrain is, in many instances, rough and broken. This necessitates extremely long canals to

transfer water from one point to another. The precise routing of canals and the length of canal needed could vary considerably from that which is included in the cost estimates, because in addition to having rough and broken terrain, the contour maps available for use throughout most of the area were somewhat limited. Therefore, the canal lengths which are included in the costing of the various plans could, it is believed, vary considerably from the estimates included in Chapter V.

Again, the assumption concerning canal lengths is a very important item, which contributes significantly to the costs associated with the various engineering plans, as presented in Chapter V

In summary, the engineering detail presented in Chapter V is intended to represent the best possible estimate of construction and O & M costs which would be associated with the various proposed plans. It is recognized that these are preliminary estimates and that, because of certain problems discussed above, these estimates could vary somewhat under actual implementation. The preceding discussion is in no way intended to discredit any of the estimates, which are included in the engineering detail in Chapter V. Much to the contrary, they point out that in assessing feasibility, such estimates should be critically analyzed, at least in part, to determine what effect would result, in terms of the overall feasibility, if the estimates were to change. This type of analysis rationale will be implemental throughout this chapter and will provide valuable insights to be examined before final feasibility judgements are rendered.

Acreage Included Under Various Assumptions

The cost per acre irrigated varies significantly as the total number of acres reached by the various systems is changed. This is true, primarily, because the capacity of the system would allow for some variances in the number of acres included under the system, with very little accompanying change in construction costs.

It must certainly be recognized that the potentially irrigable acres, as identified and described in detail in Chapter III, are the best estimates as to the total acreages and location of potentially irrigable lands. It is clearly stated in Chapter III that a detailed soil survey and other detailed work would need to be undertaken before final judgements are made as to the precise identification of potentially irrigable lands. It is also stated in Chapter

III that the acreages of potentially irrigable lands, which have been identified, probably understate the actual quantity of land which eventually proves to be potentially irrigable, given a detailed soil survey. This fact alone makes it entirely possible that the number of acres, which have been classified as potentially irrigable under each of the various plans, could vary significantly--again, a factor which would affect water cost per acre.

It was also stated in Chapter V that the potentially irrigable acres reached by the system, were identified on the basis of those lands which had previously been classified as potentially irrigable. Basically, the acreages reached were located within one-half mile of the water source and within 100-feet elevation of the water source. Again, it is possible that the actual resulting number of totally potentially irrigable acres, which would be included under each of the systems, could be at variance from what is indicated in Chapter V. Thus, this variable should be examined also, as to its effect on cost per acre before judgements relating to preliminary feasibility are made.

Construction Cost and Debt Retirement Assumed by the Irrigation User

There are many aspects to the retirement or assignment of construction costs on an annual basis.

Obviously, it is possible to compute an entirely different cost per acre, if 100 percent of the construction costs are assumed to be paid for by the irrigation project, rather than 100 percent of the construction costs plus interest payments. There are several crucial variables concerning debt retirement, which would significantly affect costs of water per irrigated acre.

The first of these variables relates to the retirement of the debt incurred during construction and the percentage of that debt which is assumed by the project. Some comparable projects have had 100 percent of the construction costs assumed, while in others, none of the construction costs are charged to the irrigation water user. This assumption is, of course, extremely significant to the designation of cost per acre, under the various proposed plans.

A second important factor, regarding the retirement costs is the portion of interest, if any, which is charged to the irrigation water user. The interest rate, itself, is also very important.

A third important consideration, with respect to the assigning of construction costs to the irrigation water user, is the number of years over which the construction cost is to be retired. This varies significantly from the 20 to 100 years for various projects. All of these factors are important and exert an impact on the costs per acre charged to the irrigation water user.

Returns From the Industrial and Municipal User

It is very obvious from the material presented in Chapter IV and also material presented in Chapter VI that the development of coal resources in the area would be greatly enhanced by water availability on-site. Tables V-I, V-J, V-K, and V-L, in Chapter V, contain various assumptions regarding returns from the industrial water user under the proposed McCone irrigation plans. These tables show the effect of water sale to an industrial user, upon the cost per irrigated acre. All of the data presented in Chapter V assumes, as an example, an annual use of 7,200 acre-feet of water with prices at $50, $75, and $100 per acre-foot.

Both the quantity of water used and the price associated with its use are very important in terms of assessing the dollar amount required per acre irrigated from the irrigation user. Therefore, these two variables representing quantity and cost of water for industrial use are, indeed, important in judging preliminary feasibility of the various systems.

In addition, the dollar return for the supplying of improved quantities and qualities of municipal water in the various municipalities of the area is also important. The expected dollar return received from the municipal water user is expected to be relatively small. However, it is clear that the quality of water now available to the people in the municipalities of the area is very poor; and as stated in Chapter VI, it is difficult to assign a specific dollar value to the improvement of water quality. It is, however, obvious that there is some associated dollar value which could logically be associated with the supplying of a more adequate supply of water, both in terms of water quantity and water quality.

B. ANALYSIS AND VARIANCE OF IMPORTANT COST VARIABLES FOR ASSESSING FEASIBILITY

Introduction

As a result of the above discussion, it is clear that many variables exist, which are of key importance to the assessment of preliminary feasibility for any one of the proposed systems, as presented in Chapter V and discussed in Chapter VII. Many of the system cost components presented in Chapter V could be expected to vary from the original estimates. In assessing preliminary feasibility, it is critical to examine the impact of the variants on total cost per irrigated acre. Certain cost components, it should be noted, can vary significantly with little effect upon the total cost, while minor variances in other cost components may exert a very significant effect.

All of the following analysis is presented in terms of varying each of the cost components by system, and observing its effect on total cost per acre irrigated. The focal point of all discussion, relative to judgments on preliminary feasibility, is focused on cost per acre irrigated under the systems. In previous sections of this report, the cost per acre irrigated under each system was examined only on a total cost basis; but, in this section the total cost per irrigated acre is broken down into its distinct components, which contribute individually to the total cost as presented in Chapter V. The cost components examined include:

1. Construction costs and debt retirement;
2. Pumping power costs;
3. Pump maintenance, labor, etc.;
4. Reduction in annual cost per acre resulting from industrial water sale.

The first item, which is examined in relationship to its contribution to the total cost per acre irrigated, under each system, is the terms of debt retirement. Table VII-A indicates the construction costs per acre, assignable to the irrigation user, assuming 100 percent user financing of the incurred debt. Table VII-B accomplishes a similar task, showing construction costs per acre, assignable to the irrigation user, assuming 50 percent user financing.

In both Tables VII-A and VII-B, three different assumptions as to interest rate are included--3.5 percent, 4.5 percent, and 5.5 percent. In addition, for each of the interest rates, there are three assumptions made, as to the

TABLE VII-A

ANNUAL ASSIGNABLE CONSTRUCTION COSTS ASSUMING 100 PERCENT REPAYMENT BY THE USER PER IRRIGATED ACRE FOR THE DIFFERENT PLANS ASSUMING VARIOUS INTEREST RATES AND YEARS FOR RETIREMENT.*

Years for Retirement	Interest Rates					
	5½	4½	3½	5½	4½	3½
	McCone A			McCone B		
40	$21.17	$18.45	$15.90	$22.42	$21.25	$19.89
50	20.05	17.20	14.48	19.56	18.20	16.40
100	18.78	15.49	12.28	18.86	15.34	13.01
	Garfield A			Garfield B		
40	$48.92	$46.35	$43.40	$56.09	$53.12	$49.74
50	42.65	39.78	35.77	48.93	45.55	40.94
100	36.75	33.47	28.37	42.17	38.38	32.55
	Garfield C			Garfield D		
40	$42.61	$40.40	$37.79	$33.48	$31.73	$29.76
50	37.17	34.62	31.16	29.32	27.13	24.51
100	32.01	29.18	24.75	25.17	22.98	19.48

*Assumes no water sale for industrial use.

TABLE VII-B

ANNUAL ASSIGNABLE CONSTRUCTION COSTS ASSUMING 50 PERCENT REPAYMENT BY THE USER PER IRRIGATED ACRE FOR THE DIFFERENT PLANS ASSUMING VARIOUS INTEREST RATES AND YEARS FOR RETIREMENT.*

Years for Retirement	Interest Rates					
	5½	4½	3½	5½	4½	3½
	McCone A			McCone B		
40	$10.59	$9.23	$7.95	$11.21	$10.62	$9.94
50	10.03	8.60	7.24	9.78	9.10	8.20
100	9.39	7.74	6.14	9.43	7.67	6.50
	Garfield A			Garfield B		
40	$24.46	$23.17	$21.70	$28.04	$26.56	$24.87
50	21.37	19.89	17.88	24.46	22.77	20.47
100	18.37	16.73	14.18	21.08	19.19	16.28
	Garfield C			Garfield D		
40	$21.30	$20.20	$28.89	$16.74	$15.86	$14.88
50	18.58	17.31	15.58	14.16	13.56	12.25
100	16.00	14.59	12.37	12.58	11.49	9.74

*Assumes no water sale for industrial use.

number of years over which the debt is to be retired. The number of years considered for retirement include 40, 50, and 100 years.

As an example, one can turn to Table VII-A, which assumes 100 percent irrigation user financing of the construction costs. For any combination of interest rate and years, in Table VII-A the assignable construction cost per acre for each proposed system can be found. Under McCone Plan A, the assignable annual construction cost per acre for irrigation water, assuming a 40-year retirement and 5.5 percent interest, would be $21.17. The corresponding cost for Garfield B, under the same assumptions, would be $56.09. Again, it is possible to determine for any one of the proposed systems, what the annual assignable construction costs per irrigated acre would be for an interest rate of 3.5 percent and a retirement term of 100 years--or for any other such combination.

No table is shown which varies the original construction cost. It is, however, recognized that this cost component will likely vary from the original estimates. Such variation is due, primarily, to the difficulty involved in accurately estimating pump costs, pipeline costs, and ditching costs. It is obvious, however, that once the annual construction costs are assigned to an irrigated acre, under any particular plan, then as the total construction varies by a given percentage, the cost assignable per acre would vary by that same percentage. For example, in Table VII-A, the annual assignable construction cost per acre for McCone Plan A is $21.17. This cost assumes 100 percent debt retirement over forty years at 5.5 percent interest. If it is assumed that the original construction costs are lowered by 20 percent, then the original cost per acre irrigated ($21.17) would also be lower by 20 percent. Identification of this relationship will enable the reader to examine various assumptions concerning this cost component.

Operation and Maintenance Cost by Category

Tables VII-C, VII-D, VII-E and VII-F each contain information as to the assignable annual cost per acre to the irrigation user under various assumptions regarding operation and maintenance (O and M) costs.

Table VII-C shows the possible variations in cost per acre for annual pumping power, under the different plans presented. Power costs are included at four specific levels --2.5, 3, 3.5, and 4 mills per KW hour. This cost component induces a very significant effect, as is clearly shown in

TABLE VII-C

VARIATIONS IN COST PER IRRIGATED ACRE FOR ANNUAL PUMPING POWER COSTS FOR DIFFERENT PLANS ASSUMING SELECTED POWER COSTS PER KW HOUR.*

	Power Cost per KW Hour			
Plan	2½ mills	3 mills	3½ mills	4 mills
McCone Plan A	$ 9.45	$11.34	$13.23	$15.12
McCone Plan B	9.70	11.64	13.58	15.52
Garfield Plan A	16.22	19.47	22.71	25.96
Garfield Plan B	9.21	11.05	12.90	14.74
Garfield Plan C	15.30	18.36	21.42	24.48
Garfield Plan D	4.92	5.90	6.88	7.87

*Assumes no water sale for industrial use.

TABLE VII-D
VARIATIONS IN COSTS PER IRRIGATED ACRE FOR ANNUAL PUMP MAINTENANCE, LABOR COST, AND OTHER MISCELLANEOUS MAINTENANCE FOR DIFFERENT PLANS ASSUMING A 10 PERCENT INCREASE OR DECREASE IN ESTIMATED COSTS.*

Plans	Study Cost Estimate	10 Percent Increase	10 Percent Decrease
McCone Plan A	$ 4.95	$ 5.45	$ 4.46
McCone Plan B	4.77	5.25	4.29
Garfield Plan A	8.52	9.37	7.67
Garfield Plan B	11.67	12.84	10.50
Garfield Plan C	7.99	8.79	7.19
Garfield Plan D	10.94	12.03	9.85

*Assumes no water sale for industrial use.

Table VII-C. For example, for Garfield Plan D, the power cost per KW hour is $5.90 per acre irrigated, assuming power at 3 mills and $4.92, assuming power at 2.5 mills. This variance of one-half mill per KW hour results in approximately one dollar per acre variation in irrigation costs.

Table VII-D shows the variations in cost per acre irrigation for annual pump maintenance, labor cost, and other miscellaneous maintenance, for the six different plans, assuming a ten percent increase or decrease in the estimated cost. This cost component does not account for a large percentage of the total cost per irrigated acre. Therefore, a ten percent change tends to have a relatively minor effect in terms of the total cost per acre irrigated under each plan. For example, in Garfield Plan C, a ten percent increase would only increase the cost per acre irrigated from a level of $7.99 to a level of $8.79.

System Efficiency

Another key variable which requires identification in the estimation of costs associated with any particular system, is the system efficiency in delivering water to the land involved. It is obvious, as pointed out in detail in Chapter V, that the canal lengths as well as the use of the stream channels tends to decrease the efficiency of the system. It is, however, recognized that this variable could vary significantly from what has been assumed in this study. The data presented in Table VII-E shows the effect of such a change. It was assumed in the construction of Table VII-E that a 20 percent increase (decrease) in the total efficiency of the system would result in a corresponding 15 percent decrease (increase) in total cost. In other words, if 20 percent less water were required in the system per acre irrigated, then the total system cost would decrease by an amount of 15 percent.

The system efficiency variable does, indeed, have a very significant impact upon total cost per acre. For example, McCone Plan A shows a study cost estimate of $26.88 per acre irrigated. Under the above assumptions, a 20 percent increase in system efficiency would lower that cost to $26.47 --accounting for a cost difference of approximately fifty cents per acre. Table VII-E is different from previous tables presented in this analysis, in that the effect of system efficiency is shown directly on the total cost per acre irrigated, while all of the other tables, VII-A through VII-D, contain data dealing specifically with particular components of the total cost. The identical type of analysis is employed in Table VII-F.

TABLE VII-E

VARIATION IN COST PER IRRIGATED ACRE ASSUMING SYSTEM EFFICIENCY CHANGES OF 20 PERCENT[1]

	Study Cost Estimate	20 Percent Decrease in System Efficiency[2]	20 Percent Increase in System Efficiency[2]
McCone Plan A	$26.88	$27.28	$26.47
McCone Plan B	27.63	28.05	27.22
Garfield Plan A	52.48	60.53	44.61
Garfield Plan B	50.77	58.38	43.15
Garfield Plan C	47.71	54.86	40.55
Garfield Plan D	33.70	38.75	28.64

[1]Assumes no water sale for industrial use and 50 percent user financing.

[2]A 20 percent increase (decrease) in system efficiency is assumed to result in an approximately 15 percent decrease (increase) in total annual cost. The new cost per acre irrigated is then computed by dividing the revised total annual cost by the original acreage served.

Acreage Reached

Table VII-F assumes a variation in the number of acres reached with each one of the proposed systems. The material contained in Table VII-F is similar to that contained in Table VII-D. In Table VII-F, it is assumed that a 20 percent increase (decrease) acreage would result in approximately a 15 percent increase (decrease) in total annual cost. In other words, it is assumed that, if the acreage covered under a particular system is increased by 20 percent, then the total costs would increase by only 15 percent.

Because of the fact that any acreage increase is in large part offset by a corresponding cost increase, the impact of varying acreage is somewhat less than might have been expected. Table VII-F, for example, shows that for McCone Plan B, a 20 percent increase in the number of acres served lowers the total cost per acre irrigated by just slightly more than four dollars. Again, this relationship is true because, as acreage served increases, the associated system costs also increase.

Industrial Water Returns

It is clear that the aspect of industrial development, in relationship to the coal reserves of the area, is a very important consideration to this study. This matter is covered in detail in Chapters IV, V, and VI of this report. The importance of coal development is impressive, especially when one looks at the possible contributions or reductions in the cost per acre irrigated, which would be associated with the sale of water for industrial use. Table VII-G contains data examining the importance of the assumption made concerning this variable.

Table VII-G contains three different assumptions, as to the acre-foot requirements of water for industrial use, as well as three prices associated with the price per acre-foot to be paid by the industrial user. The three assumed levels of use are 7,200, 10,000, and 15,000 acre-feet per year, with three different prices of $50, $75, and $100 per acre-foot. From this, it is possible to calculate the total dollar return from the industrial user. The reduction in cost per irrigated acre, which could, as an example, result under the various plans through the sale of water for industrial purposes, is shown in Table VII-G. This material is presented only for McCone Plan A and McCone Plan B, because no industrial water use has been assumed in any of the plans in Garfield County. This assumption was based on

TABLE VII-F

VARIATIONS IN COST PER IRRIGATED ACRE ASSUMING IRRIGATED LAND UNDER EACH SYSTEM IS INCREASED BY 20 PERCENT[1]

Plan	Study Cost Estimate	20 Percent Increase in Acreage Served[2]
McCone Plan A	$26.88	$22.73
McCone Plan B	27.63	23.37
Garfield Plan A	52.48	50.29
Garfield Plan B	50.77	48.65
Garfield Plan C	47.71	45.72
Garfield Plan D	33.70	32.29

[1]Assumes no water sale for industrial use and 50 percent user financing.

[2]A 20 percent change in acreage is assumed to result in an approximately 15 percent change in total annual cost. The new cost per acre irrigated is then computed by dividing the revised total annual cost by the revised acreage served.

TABLE VII-G

CONTRIBUTIONS TO COST PER IRRIGATED ACRE BY SALE OF WATER FOR INDUSTRIAL USE FOR MCCONE COUNTY

Acre Feet of Water for Industrial Use	Price for Industrial Water/acre ft.	Dollar Return from Industrial Water	Reduction in Cost per Irrigated Acre Industrial Sale	
			Plan A[1]	Plan B[2]
7,200	$ 50.00	$ 360,000	$ 9.78	$ 6.82
7,200	75.00	540,000	14.67	10.23
7,200	100.00	720,000	19.57	13.64
10,000	50.00	500,000	13.59	9.47
10,000	75.00	750,000	20.38	14.20
10,000	100.00	1,000,000	27.17	18.94
15,000	50.00	750,000	20.38	14.20
15,000	75.00	1,125,000	30.57	21.31
15,000	100.00	1,500,000	40.76	28.41

[1] Assumes 36,800 irrigable acres.

[2] Assumes 52,800 irrigable acres.

the lack of identification or of any industrial user possibilities in that specific area.

The industrial user return is, indeed, a crucial variable to the entire study. For example, Table VII-G shows that the associated reduction in cost is very significant in cost per irrigated acre, as one varies either the quantity of the water sold for industrial use or its price. Many of the reductions examined in Table VII-G exceed ten to twenty dollars per acre under the various assumptions. This variable, it cannot be overemphasized, is critical to the assessment of feasibility of the projects in McCone Plan A and McCone Plan B.

It is discussed later in this chapter, in terms of the conclusions as to preliminary feasibility, that the assumption which is made regarding the quantity and price of water sold for industrial use is probably the key or determining variable in the entire analysis. There is little doubt that a feasible project exists, at least on a preliminary basis, under either McCone Plan A or McCone Plan B, if an industrial user of water can be found. The actual water requirements and price per acre-foot could only be established at that time.

Summary

The components of total annual cost per acre irrigated for the various plans, as described above and included under various assumptions in the accompanying tables, fall into four specific categories. These categories are as follows:

1. Assigned construction costs;
2. Pumping power costs;
3. Pump maintenance, labor and other miscellaneous maintenance costs;
4. Potential reduction in annual cost per acre irrigated, resulting from the sale of water to an industrial user.

In addition to the above cost components, several other factors have been analyzed as to their expected impact on total cost per acre irrigated. These factors relate to system efficiency (Table VII-E) and acreage served under each system (Table VII-F).

It is possible, with the information contained in Tables VII-A, B, C, D, and G, to take any set of assumptions and, thus, arrive at a total cost per acre irrigated. Each of

these tables is based upon a variety of assumptions concerning each of the cost component variables. In summary, it is now possible to use any combination of these assumptions in arriving at a total annual cost per acre irrigated under a given plan

To further demonstrate the use of this data, three additional tables have been constructed; namely, Tables VII-H, VII-I, and VII-J. The data contained in Table VII-H indicates the breakdown, by cost component category, of the total annual cost per acre irrigated for each of the six proposed plans. The same set of assumptions, which were assumed in arriving at the cost per acre presented in Chapter V, are employed here Table VII-H shows the source of each component cost and also the source where this total cost per acre was previously included in the study. Examination of Table VII-H, then, reveals that for McCone Plan A, assigned construction cost per acre under the assumption of 40 years, 5.5 percent interest and 100 percent user financing is $21.17. Pumping power costs at three mills per KW hour are $11.34 and other maintenance costs are $4.95 These costs account for a total annual cost per irrigated acre of $37.46. As a reference, Table V-H in Chapter V, showed an estimated cost per acre under this exact set of assumptions of $37.45--the slight difference results from rounding. Likewise, the same data is included for the other five plans under the assumption of 100 percent user financing (Table VII-H) Table VII-I presents an identical itemization of annual costs per irrigated acre, assuming 50 percent user financing. Again, each of the six plans has been costed, on a total cost per acre basis, in Chapter V, under the exact assumptions contained in Table VII-I.

Table VII-J accomplishes the same task as did Table VII-H and Table VII-I, but also includes assumptions concerning the potential reduction in per acre costs, which could result under various assumptions regarding the sale of water to an industrial user Portions of the data presented in Table VII-J were also presented in Chapter V.

To again demonstrate the use of data presented in the accompanying tables, an annual cost per acre irrigated for McCone Plan B may be constructed under the following assumptions:

1. 50 percent of the construction costs paid by the irrigation user;
2. Debt financed over 50 years;
3. Interest rate 4.5 percent;

CHAPTER VII

PRELIMINARY ANALYSIS OF PROPOSED SYSTEMS FEASIBILITY

TABLE VII-H

BREAKDOWN BY COST CATEGORY OF TOTAL ANNUAL COST PER IRRIGATED ACRE FOR THE VARIOUS PLANS

Cost Category	Table Source	McCone A	McCone B	Garfield A	Garfield B	Garfield C	Garfield D
				100% USER FINANCING			
Assigned Construction costs, 40 yrs. 5½%	VII-A	$21.17	$22.42	$58.92	$56.09	$42.61	$33.48
Pumping Power Costs (3 mills per KW hr.)	VII-C	11.34	11.64	19.47	11.05	18.36	5.90
Pump Maintenance, labor costs & other misc. Maintenance	VII-D	4.95	4.77	8.52	11.67	7.99	10.94
Total Cost/Acre[1]	-	$37.46	$38.83	$76.91	$78.81	$68.96	$50.[illegible]
Estimated Cost/Acre (Chapter V)[2]	-	37.45	38.84	76.92	78.71	69.07	50.33
Table Source	-	V-H	V-H	V-G	V-G	V-G	V-G

[1] Assumes no sale of water for industrial use.

[2] Varies from above total cost/acre by amount of rounding.

TABLE VII-I
BREAKDOWN BY COST CATEGORY OF TOTAL ANNUAL COST PER IRRIGATED ACRE FOR THE VARIOUS PLANS

Cost Category	Table Source	McCone A	McCone B	Garfield A	Garfield B	Garfield C	Garfield D
				50% USER FINANCING			
Assigned Construction costs, 40 yrs. 5½%	VII-B	$10.59	$11.21	$24.46	$28.04	$21.30	$16.74
Pumping Power Costs (3 mills per KW hr.)	VII-C	11.34	11.64	19.47	11.05	18.36	5.90
Pump Maintenance, labor costs & other misc. Maintenance	VII-D	4.95	4.77	8.52	11.67	7.99	10.94
Total Cost/Acre[1]	-	$26.88	$27.62	$52.45	$50.76	$47.65	$33.58
Estimated Cost/Acre (Chapter V)[2]	-	26.88	27.63	52.48	50.77	47.71	33.70
Table Source	-	V-H	V-H	V-G	V-G	V-G	V-G

[1]Assumes no sale of water for industrial use.

[2]Varies from above total cost/acre by amount of rounding.

TABLE VII-J
COST PER ACRE IRRIGATED UNDER 100 PERCENT AND 50 PERCENT USER FINANCING ASSUMING VARIOUS INDUSTRIAL USER RETURNS- MCCONE PLAN A AND MCCONE PLAN B

Industrial Water Use Assumption	Cost Reduction from Industrial User		TOTAL COST/ACRE: 100% of Construction Paid by User		TOTAL COST/ACRE: 50% of Construction Paid by User	
	McCone A	McCone B	McCone A	McCone B	McCone A	McCone B
No Water Sale	-	-	\$37.46[1]	\$38.83[1]	\$26.88[2]	\$27.62[2]
7200 Acre-ft. @ \$50	\$ 9.78[3]	\$ 6.82[3]	27.68[4]	32.01[4]	17.10[4]	20.80[4]
7200 Acre-ft. @ \$75	14.67[3]	10.23[3]	22.79[4]	28.60[4]	12.21[4]	17.39[4]
7200 Acre-ft. @ \$100	19.57[3]	13.64[3]	17.89[4]	25.19[4]	7.31[4]	13.98[4]

[1]Source: Table VII-H

[2]Source: Table VII-I

[3]Source: Table VII-G

[4]Cost computed by difference: total cost/acre, without water sale, minus cost reduction/acre, assuming various sale prices for industrial water.

4. Power available at 2.5 mills per KW hour;
5. Maintenance cost as presented in Chapter V;
6. Sale of industrial water of 10,000 acre-feet at $75 an acre-foot.

Under this set of specific assumptions, some of which are recognizably different from those contained in Chapter V, the resulting annual cost per acre irrigated is $9.37. The per acre component costs comprising this total of $9.37 are: $9.10 construction costs retired over 50 years at 4.5 percent interest (50 percent user financing), $9.70 for pumping power at 2.5 mills and $4.77 for annual pump maintenance and other labor costs, accounting for a sub-total of $23.57 per acre irrigated. From this sub-total of $23.57, there is a reduction in cost per acre of $14.20, assumed on the basis of sale of 10,000 acre-feet of water to an industrial user at $75 per acre-foot. The resulting total cost per acre irrigated, then, is $9.37 per acre irrigated. It should be pointed out that in the above example, the system efficiency, original construction cost, and the acreages included under each proposed system are assumed exactly as they were estimated in Chapter V. Data has been included, of course, which will allow variation of any or all of these cost factors.

C. SUMMARY AND CONCLUSIONS

1. Numerous variables have been estimated in this study to arrive at the total annual cost per acre irrigated under each of the proposed plans. These variables, as discussed above, can logically be expected to vary somewhat from the estimates which are included in this study. All judgments as to feasibility should take into full account the likelihood of these variances.

2. On a preliminary feasibility basis, it would appear that the systems, as outlined for Garfield Plan A, Garfield Plan B, and Garfield Plan C are definitely of questionable feasibility. This conclusion assumes that there is to be no return to any of these systems, through the sale of industrial water. Additionally, this conclusion is based on the state of technology as we know it today. Future technological changes could certainly alter the feasibility of these plans. The conclusion reached at this time would definitely be, however, that Garfield Plan A, Garfield Plan B, and Garfield Plan C are not feasible.

3. The detailed material presented for Garfield Plan D implies that this plan warrants further study. The cost per acre of land irrigated under this plan, as presented in Chapter V, is indeed quite high. However, the variation of certain key cost components could, in fact, present a situation where this plan would be deemed feasible. It is definitely suggested that Garfield Plan D receive further detailed consideration.

4. McCone Plan A and McCone Plan B appear to be of questionable feasibility, if one does not assume a return from the sale of water to an industrial user. The costs per acre irrigated are, however, within a range which definitely indicates the need for further detailed study.

5. Little doubt exists but what McCone Plan A and McCone Plan B do suggest a high probability of feasibility, when considering industrial use of water. Preliminary feasibility is particularly apparent, under the assumption that industrial water can be sold at a minimum level of 7,200 acre-feet per year and at a price of between $50 and $100 per acre-foot. Under these assumptions, it is quite clear that McCone Plan A and McCone Plan B suggest a strong probability of developing as feasible projects.

CHAPTER VIII

PRELIMINARY ANALYSIS OF CONSERVANCY DISTRICT FEASIBILITY

PRELIMINARY ANALYSIS OF CONSERVANCY DISTRICT FEASIBILITY

A. WATER DEVELOPMENT POTENTIAL OF THE AREA

It has been clearly pointed out in this preliminary feasibility study, that a considerable amount of water development potential exists in the study area. This conclusion is substantiated by the following findings:

1. The Conservancy District Law provides an opportunity for substantially local involvement in all operations of the district. The law is also written in such a way that a major amount of responsibility is placed in the hands of the local people and the Montana Water Resources Board for organization and operation of a conservancy district to foster and promote area water development (Chapter I).

2. The study area has need for development to improve its economy. The area's economy is now characterized by declining population, employment and general economic activity (Chapter II).

3. The area has large acreages of potentially irrigable lands (Chapters III and VI).

4. The agricultural economy of the area would receive substantial benefit from water development, not only in the form of increased gross returns, but in the form of more efficient utilization of all resources (Chapters III and VI).

5. The area possesses significant coal resources, which, if developed for industrial purposes, would require large quantities of water. In turn, coal development would greatly enhance the feasibility of other water development projects in the area (Chapters IV and VII).

6. The alternative system plans, which have been studied, on a preliminary feasibility basis, suggest a strong probability of developing feasible projects, given further detailed study and research (Chapters V and VII).

7. Direct area benefits could be realized by the implementation of carefully planned water development for municipal and recreational uses, as well as for the industrial and agricultural uses discussed (Chapters III, IV, V, VI, VII).

8. Many secondary area benefits which are of extreme importance, would result from water development (Chapters II and VI).

B. CONSERVANCY DISTRICT BOUNDARIES

On the basis of this preliminary feasibility study, the recommended boundaries are as follows:

1. The northern boundary be the Missouri River and Fort Peck Reservoir beginning at a point where the Musselshell River runs into the Missouri River in the extreme north-west corner of Garfield County.

2. The western boundary is recommended to be the ridge which divides the Musselshell River drainage area from Missouri-Fort Peck drainage area. The ridge runs through the western portion of Garfield County, beginning in the extreme north-west corner of the county in T19N, R30E and ending on the southern border of Garfield County in T13N, R34E.

3. The southern boundary is recommended to be the southern boundary of Garfield and McCone Counties to that point where the southern boundary of McCone intersects the western boundary of Dawson County.

4. The eastern boundary is recommended to be the ridge in Dawson and Richland Counties which divides the Missouri-Fort Peck drainage area from the lower Yellowstone River drainage area. In addition, the northern portion of the eastern boundary, which is mainly in Richland County, is recommended to be the boundary within the Fort Peck-Missouri drainage, which divides the region in such a way that all of the Redwater River drainage is included in the district. All lands which lie to the east of the Redwater River drainage area are excluded from the recommended district.

It is strongly recommended that a detailed feasibility study for the East Central Water Conservancy District consider, in more sufficient detail, the questions of the eastern and southern boundaries of the proposed district. This preliminary survey, as formally requested, did not consider any lands to the south of the county lines of McCone and Garfield Counties. Likewise, the material

assembled in this study was bounded on the east by the Redwater drainage area in Richland County.

It is recognized, here, that further study could support the position that the boundaries be changed from those which were recommended above, on the basis of the research completed in this preliminary feasibility study. Certain of these possible changes, to be examined as suggested above, are as follows:

1. Re-define the southern boundary in such a way that it would be moved slightly to the south, to include all of Missouri-Fort Peck drainage area. This would then include extremely small portions of Rosebud and Custer Counties and a somewhat larger portion of Prairie County.

2. Re-define the eastern boundary to include all lands in Dawson and Richland Counties, which are a part of the Missouri-Fort Peck drainage. This definition would exclude those land areas which lie to the east of the Redwater River drainage.

C. THE ROLE OF THE CONSERVANCY DISTRICT

Some confusion appears to exist, with regard to the conservancy district's function in area water development. Two schools of thought apparently prevail: (1) the conservancy district as an all encompassing entity which organizes, plans and promotes water development, as well as actually constructing the works involved and (2) the conservancy district as an entity which has as its primary function the planning, organization and promotion of area water developments. Under the second approach, the assumption is advanced that some entity, other than the conservancy district, itself, could likely be involved in the construction of project works.

The second school of thought, then, provides a somewhat more objective approach to area water development. It is based upon the premise that a large, unified body, such as the conservancy district, is necessary to foster and promote water development, which would likely benefit the entire area. Such a broadly defined organization would provide a sound organizational base with sufficient muscle to see many projects through to the implementation phases. Similar projects, supported and promoted by more narrowly defined organizations would, it is believed, be less likely to succeed.

The second school of thought, it should be noted, does not make any tacit assumptions regarding the conservancy district's role in construction of project works. This more objective approach is based upon the realization that the most appropriate means of project implementation may vary among individual projects. Some water development works, it is believed, could be better implemented under previously existing water development laws. Development possibilities contained in the provisions of such laws as those pertaining to: (1) County Water and Sewer Districts, (2) Soil and Water Conservation Districts, (3) County and Municipal Participation in Flood Control and Water Conservation, (4) Rural Special Improvement Districts, (5) Irrigation Districts, (6) Drainage Districts, and others should be carefully examined before project implementation.

It is believed that for meaningful and effective area planning, some type of guiding organizational structure should precede the planning efforts. There is an apparent difference in the degree of practical applicability of various laws, stemming from the fact that certain laws are based upon organization preceding planning, while others are not.

In addition, special examination should be given the existing laws to determine their individual complexities with regard to legal requirements such as voting and court hearings. The means, which is ultimately chosen to implement the project works, should maximize the efforts contributed in the shortest time period which is realistically practical. The above discussion, however, in no way precludes the use of provisions within the Conservancy District Law for actual implementation of proposed project works.

What is definitely recommended is that serious consideration be given to the alternate methods of project implementation, while at all times keeping in mind the desired role and scope of the conservancy district itself.

There are, indeed, many functions which the conservancy district could and should perform, if organized and in operation. As stated above, this may or may not involve the actual construction and operation of any specific projects.

It is anticipated that few, if any, of the works projects would directly effect all people and land included in the conservancy district. The conservancy district should undoubtedly serve as a local, broad-based power group to study and aid in the implementation and promotion of many different types of water development.

One such example of a project, which the district could promote and help organize, but not construct or operate, would be an SCS Public Law 566 project. Many fine projects of this nature have failed to be initiated in the past, due to the lack of organized local support groups to aid in development of the project. The materials as presented in this study, identify the potentially irrigated lands. Many small projects in certain drainage areas may be feasible, given more information than is presently available.

The conservancy district should be organized in a manner which would foster and develop a maximum amount of local involvement and support for projects within the conservancy district area. Such projects would directly contribute to the socio-economic well-being of the area and its residents. The district has the power to work through, and with, all existing programs and laws available for water development projects. The district should, in no way, be operated to the disadvantage of the area residents, by failure to coordinate water development under existing and new programs, because the local people and only the local people, control the district.

On the basis of the above statements and the research performed in this preliminary feasibility study, it is strongly recommended that the local people, of the study area, carefully consider the desirability of taking the definite steps necessary to form a water conservancy district to promote and foster water development projects. In conclusion, the results of the preliminary feasibility study strongly suggest that further steps be taken toward the formation of a conservancy district in the study area.

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CHAPTER VII - PRELIMINARY ANALYSIS OF PROPOSED SYSTEMS FEASIBILITY

None

CHAPTER VIII - PRELIMINARY ANALYSIS OF CONSERVANCY DISTRICT FEASIBILITY

None

APPENDIX A

THE WATER CONSERVANCY LAW*

*Source: *Revised Codes of Montana, 1947*
(Sections 89-3401 through 89-3449 inclusive.)

CHAPTER 34 -- CONSERVANCY DISTRICTS

89-3401. Organization of conservancy districts and construction of works and public use--benefits. To provide for the conservation and development of the water and land resources of the state of Montana, conserve Montana's water for utilization for beneficial purposes within the state, and provide for the greatest beneficial use of water within this state, the organization of conservancy districts and the construction of works as defined by the act are a public use and will:

(1) be essentially for the public benefit and advantage of the people of Montana;
(2) benefit all industries of the state;
(3) encourage economic growth;
(4) indirectly benefit the state by increasing property valuations;
(5) directly benefit municipalities by providing adequate supplies of water for domestic uses;
(6) directly benefit lands irrigated or drained by works constructed;
(7) directly benefit lands now irrigated by stabilizing the flow of water in streams and by increasing the flow and return flow of water to those streams;
(8) enhance fish and wildlife habitat;
(9) improve recreational facilities; and
(10) promote the comfort, safety, and welfare of the people of Montana.

History: En. Sec. 1, Ch. 100, L. 1969.
Title of Act
An act providing for the conservation and development of water and land resources of Montana through the creation of conservancy districts.

89-3402. Purpose of act. The purpose of this act is to enable the formation of conservancy districts, comprised of area in one or more counties to promote the following purposes:

(1) prevent and control floods, erosion and sedimentation;
(2) provide for regulation of stream flows and lake levels;
(3) improve drainage and to reclaim wet or overflowed lands;
(4) promote recreation;
(5) develop and conserve water resources and related lands, forest, and wildlife resources;
(6) further provide for the conservation, development, and utilization of land and water for beneficial uses

including, but not limited to, domestic water supply, fish, industrial water supply, irrigation, livestock water supply, municipal water supply, recreation, and wildlife.

History: En. Sec 2, Ch. 100, L. 1969.

89-3403. Definitions. As used in this act unless the context clearly indicates otherwise:

(1) "District" means a conservancy district, which is a public corporation and a political subdivision of the state.

(2) "Directors" means the board of directors of a conservancy district

(3) "Elector" means a person qualified to vote under section 23 [89-3423] of this act.

(4) "Court" means the district court of the judicial district in which the largest portion of the taxable valuation of real property of the proposed district is located and within the county in which the largest portion of the taxable valuation of real property of the proposed district is located within the judicial district.

(5) "Person" means a natural person; firm; partnership; co-operative; association; public or private corporation, including the state of Montana or the United States; foundation; state agency or institution; county; municipality; district or other political subdivision of the state; federal agency or bureau; or any other legal entity.

(6) "Water board" means the state water resources board.

(7) "Board of supervisors" means the board of supervisors of the soil and water conservation district in which the largest portion of the taxable valuation of real property of the proposed district is located.

(8) "Works" means all property, rights, easements, franchises, and other facilities including, but not limited to, land, reservoirs, dams, canals, dikes, ditches, pumping units, mains, pipelines, waterworks, systems, recreational facilities, facilities for fish and wildlife, and facilities to control and correct polution.

(9) "Cost of works" means the cost of construction, acquisition, improvement, extension and development of works, including financing charges, interest, and professional services.

(10) "Applicants" means any person residing within the boundaries of the proposed district making a request for a study of the feasibility of forming a conservancy district.

(11) "Notice" means publication at least once each week for three (3) consecutive weeks in a newspaper published in each county, or if no newspaper is published in a county, a newspaper of general circulation in the county, or counties, in which a district is or will be located. The last published notice shall appear not less than five (5) days prior to any hearing or election held under this act.

(12) "Owners" are the person or persons who appear as owners of record of the legal title to real property according to the county records whether such title is held beneficially or in a fiduciary capacity, except that a person holding a title for purposes of security is not an owner nor shall he affect the previous title for purposes of this act.

(13) "Taxable valuation" shall mean the valuation determined according to section 84-302, R. C. M., 1947, and does not mean assessed valuation.

History: En. Sec. 3, Ch. 100, L. 1969.

89-3404. Preliminary survey--written request. (1) To request a preliminary survey for a proposed conservancy district, the applicants shall present a written request to the water board.

(2) The request shall:

(a) generally describe the proposed boundaries of the district;

(b) specify the purpose or purposes of the district;

(c) list the works contemplated.

(3) The water board may initiate a preliminary survey without any prior request.

History: En. Sec. 4, Ch. 100, L. 1969.

89-3405. Action by water board upon receipt of request. (1) Sooner than eleven (11) days after the request is received, the water board shall acknowledge the request.

(2) The water board shall itself, or through cooperating agencies:

(a) consult with the board of supervisors and all persons who may participate in the proposed project;

(b) conduct a preliminary survey of the proposed district;

(c) estimate costs of works, maintenance, and operation;

(d) determine sources of financing;

(e) reach a tentative decision on the feasibility,

desirability, and compatability with the state water plan of the proposed district;

(f) adjust the boundaries of the proposed district to improve the feasibility, desirability, or consistency with the state water plan;

(g) sooner than six (6) months after receipt of the request, send a report of the preliminary survey to the applicants, the board of supervisors, fish and game commission, state soil conservation committee, state board of health, and other affected state and federal resource agencies for their comments.

History: En. Sec. 5, Ch. 100, L. 1969.

89-3406 Hearing by water board. (1) Upon receipt of the preliminary survey report the applicants, or any one of them, may request the water board to hold a hearing. The water board shall hold the hearing sooner than sixty-one (61) days after receipt of the request. Notice of the hearing shall be given in accordance with section 3, subsection (11) [89-3403 (11)] of this act.

(2) If the water board itself initiated the preliminary survey, it may hold such a hearing without being requested to do so.

History: En. Sec. 6, Ch. 100, L. 1969.

89-3407. Feasibility study and report--adjustment of proposed boundaries. After the hearing, the applicants, or any one of them, may request the water board to prepare a detailed feasibility study of the proposed district. If the water board concludes that the proposed district is feasible, desirable, and consistent with the state water plan, it shall prepare a feasibility report, and sooner than six (6) months after receipt of the request, send copies to the applicants, if any, the fish and game commission, state soil conservation committee, state board of health, and other affected state and federal water resource agencies. For good cause shown based upon the actual technical problems in completing the report, the water board may use necessary additional time to complete and distribute the report. The detailed feasibility report shall describe the proposed works and contain an estimate of the cost of the works, the means of financing, and the estimated costs of operation and maintenance. The water board may adjust the boundaries of the proposed district to improve the feasibility, desirability, and consistency with the state water plan, and to exclude land which would receive no direct or indirect benefits from the proposed district.

History: En. Sec. 7, Ch. 100, L. 1969.

89-3408. Procedure for organization of district. If in the opinion of the water board the feasibility study shows that a district is feasible and consistent with the state water plan, the procedure for organization is:

(1) the water board shall file a petition requesting organization with the court;
(2) the petition shall:
(a) state the name of the proposed district;
(b) give a legal description of the boundaries of the proposed district, excluding therefrom lands which would receive no direct or indirect benefits from the proposed district;
(c) describe the purposes of the district;
(d) describe the works;
(e) indicate the estimated cost of works, means of financing, and estimated costs of operation and maintenance;
(f) list the taxable valuation of real property in the proposed district, which must be one hundred thousand dollars ($100,000) or more;
(g) describe the means of repaying capital costs;
(h) propose the persons who should be represented and the number of directors.
(3) The petition shall be signed by owners of at least fifty-one percent (51%) of the land outside the limits of an incorporated municipality, and not fewer than five percent (5%) or one hundred (100), whichever is the lesser, of the persons who would qualify as electors within an incorporated municipality.

History: En. Sec. 8, Ch. 100, L. 1969.

89-3409. Court hearing on organization petition--election --voters needed to organize--no jurisdiction to determine priority of appropriation. (1) Upon receipt of a petition for organizing a district, the court shall give notice and hold a hearing on the petition If the courts shall find that the prayer of the petition should be granted, it shall:

(a) make and file findings of fact specifying those lands that will be directly or indirectly benefited by the proposed district, and exclude those lands which will not be so benefited;
(b) make an order fixing the time and place of an organizing election;
(c) give notice of an election in the way provided in section 3, sub-section (11) [89-3403 (11)];

(d) provide for election judges and fix their compensation;

(e) fix the polling place or places as necessary;

(f) order the county clerk to provide pollbooks, ballots, poll lists, and other necessary election supplies;

(g) provide for canvassing the results;

(h) declare the results;

(i) order and decree the district organized if the requisite number of eligible electors vote in favor of organization.

(2) In order for the district to be organized, fifty-one percent (51%) or more of the eligible electors must vote in the election, and a majority of those voting must vote in favor of organization.

(3) This act shall not confer upon the court jurisdiction to hear, adjudicate, and settle questions concerning the priority of appropriation of water between districts and other persons. Jurisdiction to hear and determine priority of appropriation, and questions of right growing out of, or in any way connected with a priority of appropriation, are expressly excluded from this act and shall be determined as otherwise provided by the laws of Montana.

History: En. Sec. 9, Ch. 100, L. 1969.

89-3410. Filing of documents after organization. Sooner than thirty-one (31) days after the district has been decreed organized, the clerk of the court shall transmit to the secretary of state, water board, and to the county clerk and recorder in each of the counties having lands in the district, copies of the election results, the decree of the court incorporating the district, and a description of the boundaries of the district. Copies of the same documents shall be filed in the office of the secretary of state in the same manner as articles of incorporation are required to be filed under the laws governing corporations. Copies shall also be filed in the office of the county clerk and recorder of each county in which a part of the district may be. The clerk and recorder of each county where the articles are filed and the secretary of state shall collect filing fees as provided by law.

History: En. Sec. 10, Ch. 100, L. 1969.

89-3411. Reimbursement for expenses of organizing election. If organized, the district shall reimburse the county, or counties, for the expenses incurred in the organizing election.

History: En. Sec 11, Ch 100, L 1969.

89-3412. Appointment of directors--terms of office--vacancies--first annual meeting--corporate surety bond. If a district is organized, the court shall:

(1) establish by court order the number of persons who shall comprise the directors, appoint persons who are electors within the district to membership on the board of directors, and fix their compensation. The number shall not be less than three (3) nor more than eleven (11) persons. In fixing the number and making the appointments the court shall consider the interests and purposes to be served by the district Upon a verified petition filed by a majority of the directors and for good cause shown, the court may enlarge or reduce the membership of the directors but not to exceed eleven (11) nor to be less than three (3);

(2) fix the terms of office so that approximately one-third (1/3) of the directors first appointed shall serve for one (1) year; approximately one-third (1/3) shall serve two (2) years; and the remainder shall serve three (3) years. All succeeding terms shall be three (3) years. Unless excused for good cause, a director who misses three (3) consecutive regular meetings has vacated his position;

(3) fill all vacancies on the board by appointment or reappointment;

(4) specify a date for the first annual meeting of the directors;

(5) specify the amount and form of a corporate surety bond which each member of the directors shall furnish at the expense of the district, conditioned upon his faithful performance of his duties as a director.

History: En. Sec. 12, Ch. 100, L 1969.

89-3413. Selection of officers--bylaws and rules--minutes--regular and special meetings. (1) The directors shall select from among themselves a chairman, vice-chairman, secretary, and other necessary officers. The directors shall adopt bylaws and rules for the conduct of meetings. All official acts of the directors shall be entered in a book of minutes to be kept by the secretary.

(2) The directors shall establish times for regular meetings and may hold special meetings upon the call of the chairman or any two (2) members, and (except in case of emergency) upon at least three (3) days notice of the time, place, and purpose of the meeting.

History: En Sec. 13, Ch. 100, L. 1969.

89-3414. Powers of directors. On behalf of the district, the directors may:

(1) adopt an official seal;
(2) sue and be sued;
(3) adopt rules to promote and encourage water recreation, including requirements concerning public access areas and facilities, and rules respecting the use of reservoirs and waters, picnic sites, and other recreational areas operated by the district. Rules adopted shall be filed with the secretary of directors and shall be available to any interested party upon reasonable request;
(4) enter private property for the purposes of making surveys, provided that just compensation for actual damages is made;
(5) provide for reimbursing of its members for actual expenses;
(6) appropriate water and initiate or participate in the adjudication of streams;
(7) acquire, undertake, construct, develop, improve, maintain, and operate works and all incidental facilities;
(8) acquire by purchase, exchange, gift, lease, grant, devise, or otherwise, lands, water, water rights, or rights of way as necessary for the execution of any authorized function of the district. Title to all property (including water rights) shall be in the name of the district;
(9) merge with other special districts as hereinafter provided;
(10) hold and dispose of property as necessary or convenient in the performance of the functions of the district;
(11) call upon the county attorney or attorney general for such legal services as the district may require, or in the discretion of the directors, employ private legal counsel;
(12) withhold the delivery of water upon which there are any defaults or delinquencies of payment, and otherwise dispose of that water while the default or delinquency continues;
(13) borrow money and incur indebtedness and issue bonds to finance works as provided by this act;
(14) refund bonded indebtedness incurred by the district as provided by this act;
(15) after a hearing held in accordance with section 17 [89-3417] of this act, make assessments sufficient to meet the budgetary requirements for the coming year;
(16) contract for service, for water furnished, or for the sale of water with any person;

(17) fix and revise from time to time and collect rates, fees, and other charges for the services, facilities, or water furnished by the district to any person;

(18) allocate or reallocate unused waters of the district;

(19) co-operate with; accept grants, loans, and other assistance from; act as agent for; and enter into agreements with any and all state or federal agencies, and exercise all necessary or convenient powers in connection therewith;

(20) enter into any obligation or contract with an agency of the federal government for the construction, operation, and maintenance of works; or for the assumption as principal or guarantor of indebtedness to the United States on account of district lands under the provisions of the federal reclamation act and rules established under that act; or contract with an agency of the federal government for a water supply under any federal act providing for or permitting such a contract. However, the action must be approved by a majority of the electors voting at an election held as provided in section 24 [89-3424]. If a contract is made with an agency of the federal government, the directors may deposit bonds of the district with the United States at ninety percent (90%) of their par value, to secure the amount to be paid by the district to the United States under any contract, the interest on the bonds of the district to be applied as specified by the contract If bonds of the district are deposited with the United States, it is the duty of the directors to make an assessment sufficient to meet all payments accruing under the terms of any contract with the United States;

(21) accept appointment of the district as fiscal agent for the United States or authorization of the district to make collections of moneys for or on behalf of the United States in connection with any federal reclamation projects and the district is authorized to act and to assume the duties and liabilities incident to this action. However, the action must be approved by a majority of the electors voting at an election held as provided in section 24 [89-3424]. The directors may do all things required by federal statutes and rules and require prompt payment of all charges as a prerequisite to water service;

(22) in addition to all voted indebtedness, borrow money as necessary but the amount shall not at any one time exceed five percent (5%) of the taxable valuation of real property in the district;

(23) mortgage property owned by the district if the terms of the mortgage are not inconsistent with the provisions of a resolution authorizing the sale of bonds;

(24) use any surplus funds to purchase outstanding bonds;

(25) make contracts incidental to the performance of the district's functions, and employ and fix the compensation of employees, agents or consultants as are deemed necessary, including but not limited to, a manager, attorneys, accountants, engineers, construction and financial experts;

(26) co-operate with soil and water conservation districts to obtain agreements to carry out soil conservation measures and proper farm plans from owners of lands situated in the drainage area above each retention reservoir to be installed with federal assistance.

History: En. Sec. 14, Ch. 100, L. 1969.

89-3415. Participation in federal programs. A district organized under this act, by itself or in conjunction with others, as a sponsoring organization to participate in all federal programs including, but not limited to, the Watershed Protection and Flood Prevention Act of 1954 (68 Stat. 666), the federal Water Project Recreation Act of 1965 (79 Stat. 213), the federal Reclamation Act of 1902 (32 Stat. 388), and amendments to those acts.

History: En. Sec. 15, Ch. 100, L. 1969.

Compiler's Notes

The Watershed Protection and Flood Prevention Act of 1954, referred to in this section, is compiled in the United States Code as Tit. 16, sec. 1001 et seq. and Tit. 33, sec. 701b note. The federal Water Project Recreation Act of 1965 is compiled in the United States Code as Tit. 16, sec. 4601-12. The federal Reclamation Act of 1902 is compiled in the United States Code as Tit. 43, sec. 371 et seq.

89-3416. Assessments. (1) To the extent that anticipated revenues from rates, fees, and other charges fixed persuant to section 14, sub-section (17) [89-3414 (17)] will not be sufficient to meet the district's anticipated obligations for annual operation, maintenance, and replacement or depreciation of works, or for payment of the interest and principal on bonded indebtedness, the directors may make an assessment of not more than two (2) mills on all taxable real property in the district for the purpose of fully meeting such obligations.

(2) In addition to the assessment authorized by subsection (1), the directors may annually make an assessment of up to three (3) mills on the taxable real property in the district to pay interest and principal on bonded indebtedness.

(3) The assessments are a lien upon each lot or parcel of land within the district to the extent of the assessment on each.

(4) All assessments have the same force and effect as other liens for taxes and their collection shall be enforced in the way provided for enforcement of liens for county taxes. Assessments, if not paid, become delinquent at the same time as county taxes.

(5) Except as provided in section 29 [89-3429], approval of the electors is not required for the making of these assessments.

History: En. Sec. 16, Ch. 100, L. 1969.

89-3417. Notice of public budget hearing. (1) The directors shall, prior to the first Monday in May of each year, give notice as provided in section 3, sub-section (11) [89-3403 (11)] of this act of the intention to hold a public budget hearing. The notice shall include the date, time, place, and general agenda.

(2) At the hearing, the directors shall:
(a) review the present budget;
(b) present the budget for the next year;
(c) hear and consider protests from any elector;
(d) adopt the budget for the next year;
(e) set the assessment for the next year.

History: En. Sec. 17. Ch. 100. L. 1969.

89-3418. Directors to inform county assessor and treasurer annually concerning budget, special assessments, and realty--multi-county districts. (1) Before the second Monday in July of each year, the directors shall provide the county assessor and treasurer with:

(a) the budget for the current fiscal year;
(b) a statement of the amount of special assessments to be collected for the districts;
(c) a listing of all real property within the district.

(2) If the district is located in more than one (1) county, the directors shall provide this information to each of the county assessors and treasurers.

History: En. Sec. 18, Ch. 100, L. 1969.

89-3419. Collection of special assessments--multi-county districts--investment of surplus funds--interest. (1) The treasurer of each county in which the district is

located shall collect special assessments at the same time and in the same way as county taxes.

(2) If the district is located in more than one (1) county, all assessments collected shall be deposited with the treasurer of the county in which the assessments were collected.

(3) The directors shall direct the county treasurer to invest any surplus district funds in saving or time deposits in a state or national bank insured by the Federal Deposit Insurance Corporation or in direct obligations of the United States government payable within one hundred eighty (180) days from the time of investment. All interest collected on the deposits or investments shall be credited to the fund from which the money was withdrawn. However, five percent (5%) of the interest shall be deposited in the general fund of the county.

History: En. Sec. 19, Ch. 100, L. 1969.

89-3420. Condemnation authorized--water rights. The district may exercise the right of eminent domain in the manner provided by the law to take private property for public use, with just compensation, where the taking is necessary for the purposes of the district. Water rights as such shall not be subject to such taking, but may be taken as an incident to the condemnation of land to which such rights are appurtenant, where the taking of the land is the principal purpose of the condemnation.

History: En. Sec. 20, Ch. 100, L. 1969.

89-3421. Annual written report of directors' activities. Before August 1 of each year, the directors shall send a written report of their activities during the previous fiscal year to the court and to the water board. Reports shall be in the form, and contain the information, prescribed by the water board.

History: En Sec. 21, Ch. 100, L. 1969.

89-3422. State examiner to examine financial records --report--fee. At least once each year the state examiner shall examine the financial records of each district and file a report of the examination with the water board and court. The state examiner shall collect a fee for the examination equal to that charged irrigation districts.

History: En. Sec. 22, Ch. 100, L. 1969.

89-3423. Persons entitled to vote. (1) Only persons who are taxpayers upon and owners of real property located within the district and whose names appear upon the last completed assessment roll of some county within the district for state, county, and school district taxes are electors and shall be entitled to vote in elections, provided that:

(a) an elector need not reside within the district in order to vote;
(b) where a corporation owns taxable real property within the boundaries of the conservancy district, the authorized agent of such corporation shall be entitled to cast a vote on behalf of the corporation;
(c) where land is under contract of sale to a purchaser and the contract is recorded, only the purchaser shall have the right to vote;
(d) guardians, executors, administrators, and trustees of real property within the district, shall be entitled to cast the vote for the owner of the land.
(2) When voting, an agent of a corporation or of co-owners, or a guardian, executor, administrator, trustee, or purchaser under contract of sale, may be required to show his authority by the judges of the election.

History: En. Sec. 23, Ch. 100, L. 1969.

89-3424. Election procedures. Election procedures after organization are:

(1) The directors shall designate the polling places, at least one (1) in each county, and hours when the polls will be open;
(2) Notice shall be published of the location of polling places and hours when the polls are open as provided in section 3, sub-section (11) [89-3403 (11)] of this act;
(3) The directors shall appoint three (3) judges for each polling place and fix their compensation;
(4) The judges shall appoint one (1) of their number as clerk of the election;
(5) The clerks and recorders of the counties in which the election is to be held shall supply poll lists, registers, ballots, and other necessary election supplies;
(6) The judges shall cause the ballots to be counted and certify the results to the directors;
(7) The directors shall canvass the returns;
(8) The directors shall reimburse the counties for actual expenses incurred in the election.

History: En. Sec. 24, Ch. 100, L. 1969.

89-3425. Challenging voters--oath--penalty for false subscription. An elector may challenge any person who claims the right to vote. Before voting, any person challenged must take and sign the following oath or affirmation administered by an election judge:

"I ______________(name) solemnly swear (or affirm) that I am an elector of the district and have not voted today."

False subscription to the oath or affirmation is perjury and punishable as such.

History: En. Sec. 25, Ch. 100, L. 1969.

89-3426. Issuance of bonds--maximum term and interest rate--sale as single issue of multi-purpose bonds. A district may issue bonds payable from revenues, assessments, or both, or the district may use other financing as provided by this act for the cost of works. Bonds issued shall be for a maximum term of not to exceed forty (40) years and a maximum rate of interest not more than six percent (6%). Bonds for more than one purpose may be sold as a single issue.

History: En. Sec. 26, Ch. 100, L. 1969.

89-3427. Determination of amount of bonds to be issued. In determining the amount of bonds to be issued, the directors may include:

(1) all costs of works;

(2) all costs and estimated costs of issuance of the bonds;

(3) interest which they estimate will accrue on money borrowed during the construction period and for six (6) months after the period.

History: En. Sec. 27, Ch. 100, L. 1969.

89-3428. Resolution for issuance of bonds--notice--election. When the directors find it necessary to issue bonds, the directors shall:

(1) pass a resolution which includes:

(a) the purpose or purposes for which the bonds will be issued;

(b) the maximum amount and term of the bonds;

(c) the maximum interest rate the bonds will bear;

(d) whether the bonds will be repaid from revenues, assessments, or both.

(2) give notice as provided in section 3, sub-section (11) [89-3403 (11)] of this act which shall include the

resolution adopted by the directors, location of polling places, and hours when the polls will be open;

(3) hold an election as provided by section 24 [89-3424] of this act.

History: En. Sec. 28, Ch. 100, L. 1969.

89-3429. Approval of bond issue at election--authorizes assessments--recording of election results--validity of election--single proposition. (1) For a bond issue to be approved, forty percent (40%) of the qualified electors must vote thereon, and sixty percent (60%) of those voting must approve the issue.

(2) Approval of the bond issue shall authorize the directors to make assessments as provided in section 16 [89-3416] necessary to pay the principal and interest on bonds issued.

(3) The directors shall enter the results of the election in their records.

(4) If otherwise fairly conducted, no irregularities or informalities shall invalidate the election.

(5) Bonds for more than one purpose may be submitted to the electors as a single proposition.

History: En. Sec. 29, Ch. 100, L. 1969.

89-3430. Resolution providing for form, execution and issuance of bonds--bids--private sale--sale price--rejection of bids. If a bond issue is approved, the directors shall by resolution provide for the form and execution of the bonds and for issuance of all or any part of the bonds. After adequate notice that sealed proposals will be received, the directors may award the purchase of all or a part of the issue to the best bidder or bidders, and may sell at private sale any or all bonds not sold on bids.

The said bonds will be sold for not less than their par value with accrued interest to date of delivery, and all bidders must state the lowest rate of interest at which they will purchase the bonds at par. The board shall reserve the right to reject any and all bids and to sell the said bonds at private sale.

History: En. Sec. 30, Ch. 100, L. 1969.

89-3431. Comparable to municipal bonds--exempt from taxation. Bonds issued under this act have the same force, value, and use as bonds issued by a municipality and are exempt from taxation as property within the state of Montana.

History: En. Sec. 31, Ch. 100, L. 1969.

89-3432. Interim receipts--negotiability. Pending preparation of the bonds sold under this act, receipts or certificates may be issued to purchasers in the form, and with provisions, as determined by the directors. Bonds and interim receipts or certificates are fully negotiable as provided by the Uniform Commercial Code--Investment Securities

History: En. Sec. 32, Ch. 100, L. 1969.

89-3433. Registration of bonds--copy to be furnished county treasurer. (1) When duly executed, all bonds issued under this act shall be registered by the county treasurer of the county in which the largest portion of the taxable valuation of real property of the district is located. They shall be registered in a book provided for that purpose before being delivered to the purchaser.

(2) The registration shall show:
(a) the number and amount of each bond;
(b) the date of issue and date redeemable;
(c) the name of the purchaser;
(d) the amount and due date of all payments required on the bonds.

(3) The directors shall provide the county treasurer with an unsigned and canceled printed copy of each issue of bonds of the district. The copy shall be preserved in his office.

History: En. Sec. 33, Ch. 100, L. 1969.

89-3434. Deposit of sales proceeds--disposition--investment (1) Proceeds from the sales of bonds shall be deposited with the county in which the largest portion of the taxable valuation of real property of the district is located.

(2) The county treasurer shall place the proceeds of the bond sale to the credit of the district. The proceeds shall be paid by the county treasurer on written order of the directors. Proceeds shall only be spent for the purposes for which the bonds were issued.

(3) The directors shall instruct the county treasurer to deposit any part of the proceeds which is not immediately needed for the purpose for which the bonds were issued in a saving or time deposit in a state or national bank insured by the Federal Deposit Insurance Corporation or to invest

in direct obligations of the United States government. The obligations shall be payable within not to exceed one hundred eighty (180) days from the time of deposit or investment.

History: En. Sec. 34, Ch 100, L. 1969.

89-3435. Refunding bonds authorized--redemption. (1) Refunding bonds may be issued in the same way as any other bonds authorized by this act.

(2) All bonds, original issue or refunding issue, shall be redeemable when one-half (1/2) of the term or ten (10) years of the term for which they were issued, whichever may be the less, has expired. Redemption may be made on any interest due date of any bond prior to its maturity after the bond shall be subject to redemption as herein provided. The right of redemption, as herein provided, must be stated on the face of each bond.

History: En Sec. 35, Ch 100, L. 1969.

89-3436. Fund for retirement of bonds--investment and disbursement. Revenue, assessment, and other funds on hand, including reserves pledged for the payment and security of outstanding bonds may be deposited in a fund created for the retirement of bonds and may be invested and disbursed as provided by this act, to the extent consistent with the resolution authorizing the outstanding bonds.

History: En Sec. 36, Ch. 100, L. 1969.

89-3437. Revolving funds--purpose--excess money--funds deposited with county treasurer. (1) The directors by resolution may establish revolving funds to finance, on a reimbursable basis:

(a) construction, purchase, lease, and operation of revenue-producing works;
(b) contracts to provide services or facilities.
(2) Money in the revolving fund shall not be spent for any purposes other than those specified in the resolution. However, excess money may be transferred to any sinking and interest fund of the district.
(3) The county treasurer of the county having the largest portion of the taxable valuation of real property of the district shall maintain a separate account for each revolving fund of the district, and all money collected under the resolution shall be deposited with the county treasurer.

History: En Sec. 37, Ch 100, L. 1969.

89-3438. Petition for merger of districts--hearing and notice--merger into new district--inclusion in another district--majority of electors may kill merger by petition--existing obligations (1) In case two (2) or more districts have been organized in a territory which, in the opinion of the directors of each of the districts, should constitute but one (1) district, the directors of the districts may petition the court for an order merging the districts into a single district. The petition shall be filed in the office of the clerk of the district court in and for that county which has the largest portion of taxable valuation of property within the districts sought to be included, as shown by the tax rolls of the respective counties The petition shall set forth facts showing that the purposes of this act would be served by the merging of the districts, and that the merger would promote the economical execution of the purposes for which the districts were organized A copy of the petition shall be filed with the water board

(2) Upon the filing of the petition, the court shall by order fix a time and place of hearing; and the clerk shall give notice as specified in section 3, sub-section (11) [89-3403 (11)] of this act as well as by mail to the directors of the districts which would be merged. The notice shall contain the purpose, time, and the place of the hearing

(3) Upon the hearing, should the court find that the averments of the petition are true and that the districts, or any of them, could feasibly and profitably be merged, it shall order that the merger take place and the districts shall be merged into one (1) district and proceed as such. The court shall designate the corporate name of the district, and further proceedings shall be taken as provided for in this act The court shall by order appoint the directors of the district, who shall thereafter have powers and be subject to rules as are provided for directors in districts created in the first instance.

(4) Instead of organizing a new district from the constituent districts, the court may, in its discretion, direct that one (1) or more of the districts described in the petition be included in another of the districts, which other shall continue under its original corporate name and organization; or the court may direct that the district or districts so absorbed shall be represented on the directors of the original districts, designating what members of the directors of the orignal district shall be retired from the new board, and what members representing the included district or districts shall take their places.

(5) If the court receives a petition opposing the merger, signed by a majority of the electors of any of the concerned districts, the court shall not grant the order and shall dismiss the petition.

(6) Upon merger or inclusion, existing obligations shall remain exclusively with those who bore them prior to the merger or inclusion, except with the written consent, given prior to the merger or inclusion, of those who did not bear the obligations.

History: En. Sec. 38, Ch. 100, L. 1969.

89-3439. Procedure for annexing realty. To annex real property to the district, the procedure is:

(1) The directors shall petition the court.

(2) The petition shall:

(a) give a general description of the real property to be annexed sufficient to enable a person to determine if his property is in the proposed annexation;

(b) describe the benefits to accrue to the real property as a result of the annexation.

(3) The court shall:

(a) give notice and hold a hearing on the petition;

(b) upon good cause shown, order or deny the annexation.

History: En. Sec. 39, Ch. 100, L. 1969.

89-3440. Pre-annexation bonds not lien without prior agreement. Real property annexed to a district shall not incur any liens by reason of bonds issued before annexation unless agreed to by the owners of the annexed property, in writing, prior to annexation

History: En. Sec. 40, Ch. 100, L. 1969.

89-3441. Exclusion of territory from district--procedure. Any territory included within any district formed under the provisions of this act, and not benefited in any manner by such district, or its inclusion therein, may be excluded therefrom.

The procedure for exclusion is:

(1) A petition for exclusion shall be initiated by either the directors or the owner or owners of the land sought to be excluded.

(2) The petition shall give a description of the territory sought to be excluded sufficient to enable a person

to determine if his property is in the proposed exclusion and shall set forth that such territory is not benefited in any manner by the district or its continued inclusion therein, and shall request that such territory be excluded from the district.

(3) When owners of property initiate the petition for exclusion, the petition shall be filed with the secretary of the district and shall be accompanied by a deposit of one hundred dollars ($100) to meet the costs incident to the process of exclusion. The unexpended balance of the deposit shall be returned to the petitioner.

(4) Upon the filing of such petition with the secretary of the district, the secretary shall duly call a meeting of the directors to consider the petition. The directors shall approve or disapprove of the merits of the petition. The secretary shall then file the petition, together with a copy of the action of the directors, with the court.

(5) The court shall give notice, hold a hearing, and issue an order either granting or denying the petition.

History: En. Sec. 41, Ch. 100, L. 1969.

89-3442. Procedure for dissolution of district. (1) The procedure for dissolution of a district is:

(a) a resolution shall be passed by the directors requesting dissolution; or

(b) a petition signed by twenty percent (20%) of the electors representing ten percent (10%) of the taxable valuation of real property in the district shall be presented to the directors; or

(c) if the district or its directors have been inactive for one (1) year or more, any elector may present a petition.

(2) The resolution or petition shall be presented to the court by the directors, or by the petitioners if the directors remain inactive.

(3) Not more than one (1) resolution or petition may be presented to the court in any twenty-four (24) month period, and no such petition may be presented during the first twenty-four (24) months after a district's initial organization.

History: En. Sec. 42, Ch. 100, L. 1969.

89-3443. Dissolution election--majority approval required. (1) After receipt of petition or resolution for dissolution, the court shall order an election in the way provided by section 24 [89-3424] of this act.

(2) For dissolution to be approved, a majority of the electors voting must favor dissolution.

History: En Sec 43, Ch. 100, L. 1969.

89-3444. Submission of termination plan--termination by directors or receiver--court order--retention of jurisdiction. (1) In the event the vote is for dissolution, any qualified elector, or the board of directors of the district may, within the time fixed by the court, present a written plan for terminating the affairs of the district which shall include assignment of any water rights and works owned by the district.

(2) The plan may specify that the affairs of the district shall be terminated by the directors or by a receiver appointed by the court.

(3) On a day fixed by the court, the court shall consider the plan or plans and shall enter an order establishing a plan for the termination of the affairs.

(4) The court shall retain jurisdiction to modify the plan and shall supervise the termination.

History: En Sec. 44, Ch. 100, L. 1969.

89-3445. Appointment of receiver--directors' authority ceases--assessments by receiver--annual assessments--disposition of assessments. (1) If no plan is presented on or before the date set by the court, the court shall appoint a receiver to terminate the affairs of the district under the supervision of the court.

(2) Upon the appointment of any receiver all the authority of the directors shall cease. However, until dissolution, the receiver shall have authority to levy assessments for:

(a) the payment of obligations of the district;

(b) the costs of termination;

(3) The directors, or if there is a receiver, then the receiver with the approval of the court, shall make assessments each year in an amount large enough to retire the obligations of the district.

(4) If a receiver has been appointed, he shall direct, under court supervision, the disposition of all assessments collected.

History: En. Sec. 45, Ch. 100, L. 1969.

89-3446. Entry of dissolution order--certified copy. When it appears to the satisfaction of the court that:

(1) all obligations of the district have been discharged;
(2) all the costs of termination have been paid, the court shall enter an order dissolving the district. A certified copy of the order shall be recorded by the clerk of the court in all counties in which the district was situated and filed with the secretary of state.

History: En Sec 46, Ch 100, L 1969.

89-3447. County general funds to receive funds remaining after dissolution--proportion. All funds remaining after dissolution of a district shall be deposited in the general fund of the counties in which the district is located in proportion to the taxable value of property within the district in each county.

History: En. Sec. 47, Ch. 100, L 1969.

89-3448. No power to generate, distribute, or sell electric energy. Nothing in this act shall be construed to grant to the district the power to generate, distribute, or sell electric energy

History: En Sec. 48, Ch 100. L 1969.

89-3449. Other agencies not affected. The provisions of this act shall not be construed to, in any manner, abrogate or limit the rights, powers, duties, and functions of the water board, state soil conservation committee, soil and water conservation districts, state board of health, or the fish and game commission; but shall be held to be supplementary thereto and in aid thereof

History: En Sec 49, Ch 100, L 1969

Separability Clause
Section 50 of Ch 100, Laws 1969 read "It is the intent of the legislative assembly that if a part of this act is invalid, all valid parts that are severable from the invalid part remain in effect If a part of this act is invalid in one or more of its applications, the part remains in effect in all valid applications that are severable from the invalid applications."
Effective Date
Section 51 of Ch. 100, Laws 1969 provided the act should be in effect from and after its passage and approval. Approved February 24, 1969

APPENDIX B

DETAILED DESCRIPTIONS OF MAJOR AREA SOIL SERIES*

*Source: U.S. Soil Conservation Service - National Cooperative Soil Survey.

Note All series descriptions are subject to revision.

BAINVILLE SERIES

The Bainville series is a member of fine-silty, mixed, calcareous, mesic family of Ustic Torriorthents. Typically these soils have weak horizonation in light olive brown to pale yellow calcareous silt loam resting on calcareous soft platy shale or fine grained sandstone at depths of between 20 and 40 inches.

Typifying Pedon: Bainville silt loam - native cover (Colors are for dry soil unless otherwise noted.)

A1 - 0-4" Light olive brown (2.5Y 5/3) silt loam, olive brown (2.5Y 4/3) moist; weak coarse platy structure; slightly hard, very friable; slight effervescence; clear irregular boundary (2 to 6 inches thick).

C1 - 4-17" Pale olive (5Y 6/3) silt loam, olive (5Y 5/3) moist; very weak coarse blocky breaking to coarse platy structure in lower part; hard, very friable; strong effervescence; clear boundary (4 to 20 inches thick).

C2 - 17-24" Pale yellow (5Y 7/3) silt loam, pale olive (5Y 6/3) moist; abundant soft platy shale or sandstone easily broken down with the fingers; strong effervescence; clear boundary.

R - 24+" Soft, fine grained, calcareous sandstone or loamy calcareous shale.

Type Location: Treasure County, Montana, along county road in NW¼ or SW¼, Section 26, T3N, R36E.

Range in Characteristics: Bainville soils are dry between depths of 4 and 12 inches during July through October. Mean annual temperature is more than 47 degrees F. Depth to soft platy shale or sandstone ranges from 20 to 40 inches. Hard bedrock strata may occur below 40 inches. Soil colors have hues ranging from 10YR to 5Y. The A1 horizon may be noncalcareous and has values as dark as 5 dry and 3 moist if less than 5 inches thick. Chroma are 2 or 3 throughout the soil. C horizons have values of 6 or 7 dry, 4 or 5 moist. Texture below 10 inches ranges from silt loam to clay loam with from 18 to 35 percent clay and less than 15 percent sand coarser than very fine sand.

Competing Series and Their Differentiae: These include the Genola and Midway series. The Genola soils are deeper than 40 inches to any bedrock and they are dry for more than half the time in all parts above 12-inch depth. The Midway soils have shale substrata within

depths of 20 inches and they have clayey textures.

Setting: The Bainville soils occupy hills and valley sides in an undulating to hilly landscape on plains underlain by calcareous soft shales and sandstones. These sedimentary parent rocks are of mixed mineral materials. The climate is cool semiarid with an average annual rainfall ranging from 8 to 14 inches, mean annual temperature ranging from 44 to 50 degrees F., an average summer temperature of 65 to 70 degrees F., and an average January temperature ranging from 17 to 24 degrees F. Warm season rainfall ranges from 7 to 10 inches.

Principal Associated Soils: Cushman, Elso, Lambert, McRae, Midway and Worland soils are principally associated with the Bainville soils. Cushman soils are on the smoother uplands and have B horizons. Lambert and McRae soils occur on lower slopes and in valley bottoms of more hilly landscapes. Elso, Midway and Worland soils occur on the upper slopes of the hilly landscapes and have respectively loamy, fine and coarse loamy textured control sections on soft bedrock substrata.

Drainage and Permeability: Excessively drained; runoff is rapid; permeability is moderate.

Use and Vegetation: Used mainly for range on short grasses. Areas of gentler slopes are farmed along with larger areas of Cushman, Chama, and Morton soils.

Distribution: Southeastern Montana, western South Dakota, and northeastern Wyoming.

Series Established: Northern Plains of Montana, 1929.

Remarks: Bainville soils were formerly classified with the Lithosols soil group. They have an ochric epipedon and no diagnostic subsurface horizons.

BOWDOIN SERIES

The Bowdoin series comprises deep, well drained or moderately well drained Alluvial soils intergrading to Grumusols, developed in clay materials. This series has weak or no horizonation. The soil profile has nearly continuous very hard massive, crusty or blocky surface layer, a massive or weak blocky clay subsoil layer with very few or no pores and bulk densities of 1.8 or more; a clay content in excess of 70 percent; nonsaline and nonsodic conditions with neutral to slightly alkaline reaction, and 2 to 4 inch wide cracks forming polyhedroms 1 to 3 feet or more in size

and extending deep into the subsoil. The Bowdoin series differs from the Marias series in having: (1) more clay throughout; (2) a crusty, massive, or blocky rather than a granular A1 or Ap; and (3) a higher bulk density. It lacks the high exchangeable sodium as in the Vananda series. It is better drained than the Wolf Point series and has massive subsoils rather than the distinctive fragmental platy structure in the subsoil of the Wolf Point series. It occupies better drained positions than the McKenzie series, and it lacks the Solonetz characteristics and the high alkaline reaction of this series. It is finer textured throughout than the associated Lohmiller series. The Bowdoin series is moderately extensive, widely distributed, and is important mainly for native hayland.

Soil Profile: Bowdoin clay, native hayland

Ap1 - 0-½" Gray (5Y 5/1) heavy clay (70%); 5Y 3/1 when moist; crust which breaks to weak very fine blocks; extremely hard, firm, very sticky and very plastic; very weakly calcareous; pH 8.2.

Ap2 - ½-6" Dark gray (5Y 4/1) heavy clay (75%); 5Y 3/2 when moist; weak to moderate blocky structure; extremely hard, firm, very sticky and very plastic; very weakly calcareous; pH 8.0; cracks 2 to 4 inches wide forming polyhedroms 1 to 3 feet or more across.

C1 - 6-14" Dark gray (5Y 4/1) heavy clay (80%); 5Y 3/2 when moist; massive structure breaking to very weak fine blocks when dry; extremely hard, very firm, very sticky and very plastic; very weakly calcareous; pH 8.0; very few or no pores; bulk density of 1.8 or more; 2 to 4 inch wide cracks extend down through this layer.

C2 - 14-34" Dark gray (5Y 4/1) heavy clay; 5Y 3/2 when moist; massive structure; extremely hard, very firm; very sticky and very plastic; very weakly calcareous; pH 8.0; few seams of gypsum in lower part and an occasional fine speck of lime; no pores, bulk density of 1.8 or more.

C3 - 34-60" Grayish brown (2.5Y 5/2) heavy clay (70-80%) 2.5Y 4/2 when moist; massive structure; extremely hard, very firm, very sticky and very plastic; very weakly calcareous. with an occasional thread of gypsum; pH 8.2; no pores; few yellowish brown mottlings.

Range in Characteristics: Clay is the dominant type of the series; however, other types can be recognized if the control section

below a depth of 6 to 10 inches has characteristics of the series as described. The color of materials is primarily that of the parent materials and will range from 4 to 6 in value of dry soil and 1 to 3 in chroma in the 2.5Y or 5Y hues. The clay content is usually 70 to 85 percent. Areas with clay content as low as 60 percent are included if other characteristics are similar. A substratum of stratified loamy to sandy materials may be present at any depth below 20 inches, which will be recognized as phases. Higher amounts of soluble salts are present where soil receives seepage by irrigation. In undistrubed areas, there is a thin ½-1" thick hard crust which separates to fine blocks. Colors are of dry soil unless otherwise stated.

Topography: Flat terraces and bottomlands to gently sloping fans.

Drainage and Permeability: Surface runoff is very slow on the flatter areas. Internal drainage is good. Permeability is very slow. The wide cracks provide primary means of moisture entry.

Vegetation: The undisturbed areas support sparse stands of western wheatgrass, big sagebrush and scattered greasewood.

Use: Primarily for production of native western wheatgrass hay under flood irrigation and few areas are farmed but with little success. Extensive areas are still in native cover or have been abandoned.

Distribution: Widely throughout the valleys of northern Great Plains.

Type Location: Blaine County, Montana, 900 feet west and 500 feet south of NW corner Section 36, T31N, R25E.

Series Established: Milk River area, Montana, 1928.

CHAMA SERIES

The Chama series is a member of a fine carbonatic frigid family in Typic Haplustolls. Typically these soils have non-calcareous silt loam Ap and B2 horizons in a solum less than 10 inches thick, and silt loam B3 and C horizons with a calcic horizon in the upper part of the C horizon.

Typifying Pedon: Chama silt loam, cultivated
(Colors are for dry soils unless otherwise noted.)

Ap - 0-5" Grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate fine granular structure; soft, very friable, slightly sticky and

slightly plastic; noncalcareous.

B2 - 5-10" Grayish brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) moist; weak coarse prismatic structure separating to weak fine subangular blocks; slightly hard, very friable, slightly sticky and slightly plastic; noncalcareous; clear wavy boundary; 2 to 5 inches thick.

B3ca - 10-16" Light yellowish brown (2.5Y 6/3) silt loam, light olive brown (2.5Y 5/3) moist; weak coarse prismatic structure slightly hard, very friable, slightly sticky and slightly plastic; strongly calcareous; gradual boundary; 3 to 6 inches thick.

C1ca - 16-30" Pale yellow (2.5Y 7/3) silt loam, light olive brown (2.5Y 5/4) moist; weak coarse blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; very strongly calcareous with lime disseminated and segregated in soft masses or nodules; gradual boundary 10 to 20 inches thick.

C2 - 30-45" Light yellowish brown (2.5Y 6/3) silt loam, light olive brown (2.5Y 5/4) moist; massive structure; soft, very friable, slightly sticky and slightly plastic; strongly calcareous; diffused boundary; 10 to 20 inches thick.

IIR - 45-60+" Pale yellow (2.5Y 7/4) soft siltstones, light yellowish brown (2.5Y 6/4) moist; platy structure; hard and brittle, friable; strongly calcareous.

Type Location: Wibaux County, Montana, Section 26, T17N, R59E, about 500 feet east of SW corner of section.

Range in Characteristics: The depth to a paralithic contact is usually more than 60 inches but can be within a depth of 40 to 60 inches. The mineralogy is mixed but with more than 15 percent $CaCo_3$ equivalent of which more than one-third is clay-sized. The mean annual soil temperature is about 42 to 47 degrees F. (5 to 8 degrees C.). The average summer soil temperature at 20 inches is about 62 to 65 degrees F. (17 to 19 degrees C.). These soils are usually moist in some subhorizon between 7 and 20 inches when not frozen, but will be dry in some subhorizon for 90 cumulative days or more. These soils are frozen to depths of 24 inches or more for more than 100 consecutive days in most years. Silt loam and loam are the principal textures of the A1 or Ap horizons. It has colors with values of 5 dry and 3 or less moist, chroma of 2 or 3 in hues of 2.5Y or 10YR. The control section is silt loam or loam with 18 to 27 percent clay and less than 15 percent coarser than very fine sand. The B2 horizons have weak to moderate grades of

structure, have colors with chroma of 2 or 3 in hues of 10YR to 2.5Y and are usually noncalcareous but may be weakly calcareous in some pedons. The Ca horizons have 20 to 40 percent $CaCO_3$ equivalent. The noncalcareous solum is 7 to 10 inches thick.

Competing Series and Their Differentiae: These include the Amsterdam, Polson, and Sen series in the same family; the Creston, Kalispell, Quigley, Shambo and Talley series in the same subgroup; and the Andes, Judith and Manhattan series in the same suborder. The Amsterdam and Sen soils have thicker noncalcareous solums over the calcic horizons, and the Amsterdam soils have a high proportion of volcanic glass in the lower part of the control section. The Andes soils lack the B2 and calcic horizons and have a paralithic contact within 40 inches. The Creston soils have less clay in the control section and lack the calcic horizon, being in a coarse silty family. The Judith soils lack the B2 horizons in a loam control section. The Kalispell soils have a light loam textured control section and lack the calcic horizon. The Polson soils have a silty clay loam control section rather than silt loam and lack the calcic horizon. The Quigley and Shambo soils have loam control sections and the latter lack the calcic horizon. The Tally soils have fine sandy loam control section and no calcic horizon.

Setting: The Chama soils occur on nearly level to sloping fans and terraces and on undulating to rolling sedimentary uplands. The regolith consists of silt loam materials deposited as loess, alluvium, or as deeply weathered residium from siltstone. The climate is cool, moist, semiarid, continental with cold dry winters and warm moist summers. The mean annual precipitation is 12 to 15 inches. The mean annual air temperature is 40 to 44 degrees F., mean January temperature is 16 to 22 degrees F., and mean July temperature 65 to 70 degrees F. The frost free period is 115 to 125 days.

Principal Associated Soils: These include the Andes, Cabba, and Sen series. The Andes soils have moderately dark colored Ap horizons resting on light colored C horizons. The Cabba soils have light colored Ap horizons and are less than 20 inches deep to paralithic contact, and the Sen soils have moderately dark colored Ap horizons and a cambic horizon in moderately thick noncalcareous solums.

Drainage and Permeability: Well drained with moderate to rapid runoff; moderate infiltration. Permeability is moderately slow.

Use and Vegetation: The Chama soils are used mainly for non-irrigated cropland and rangeland. The primary vegetation is western wheatgrass, needle and thread, prairie junegrass and blue grama.

Distribution and Extent: The Chama series occurs throughout the eastern plains of Montana, western North Dakota, and north-western South Dakota. It is an extensive series.

Series Established: Wibaux County, Montana, 1956. Name is that of a small town in Golden Valley County, North Dakota.

Remarks: The Chama series was formerly classified as a Chestnut soil.

CHERRY SERIES

The Cherry series is a member of the fine-silty, mixed, frigid family of Ustollic Camborthids. This classification is tentative (see "Remarks"). Typically, the soil has a grayish brown silty clay loam A1 horizon less than 4 inches thick and calcareous silty clay loam B2 horizons that have weak or moderate prismatic structure, and calcareous silty clay C horizons.

Typifying Pedon: Cherry silty clay loam - native grass
(Colors are for dry soil unless otherwise stated.)

A1 - 0-3" Grayish brown (2.5Y 5/2) silty clay loam, very dark grayish brown (2.5Y 3/2) moist; moderate medium subangular blocky structure; hard, friable; many roots; many fine pores; mildly alkaline; abrupt smooth boundary. (1 to 4 inches thick)

B21 - 3-15" Grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; moderate coarse prismatic and moderate medium and fine angular blocky structure; friable; common roots; common fine pores; few thin clay films on faces of prisms; many fine lime threads; calcareous, moderately alkaline; gradual wavy boundary. (5 to 14 inches thick)

B22 - 15-33" Grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak coarse prismatic and strong medium and fine subangular blocky structure; friable; few roots; common fine pores; many fine lime threads; moderately calcareous, moderately alkaline; gradual wavy boundary. (0 to 16 inches thick)

C1 - 33-60" Light olive gray (5Y 6/2) silty clay, olive gray (5Y 4/2) moist; moderate medium and fine subangular blocky structure; friable; strongly calcareous, moderately alkaline.

Type Location: Stark County, North Dakota; 427 feet NE of SW corner, Section 5, T138N, R93W.

Range in Characteristics: The solum is 20 to 36 inches thick to slightly weathered sediments. The solum is mainly silty clay loam containing less than 35 percent clay and less than 15 percent fine and coarser sand. The soil is frozen to depths of 24 inches for 120 days. In most years, the soil is moist in all parts above 12 inches for more than half of the time during the growing season. The mean annual soil temperature is less than 47 degrees F. The A1 horizon has hue of 2.5Y or 10YR, value of 5 or 6 dry and 3 or 4 moist, and chroma of 2 or 3. It is commonly silt loam or silty clay loam, but some is clay or loam. In some pedons the A1 horizon has moderate fine granular structure. The horizons below the A horizon commonly have hue of 2.5Y or 10YR, but hue is 5Y in places where the parent sediments have this hue. The B horizon has moderate or weak prismatic and blocky structure and has horizontal breakage or platiness inherited from the stratification of parent sediments. The more strongly calcareous C horizon has a greater number of threads and nodules of lime than the B horizon. In some pedons below depths of 40 inches the C horizon has finer or coarser textures than that of the typifying pedon.

Competing Series and Their Differentiae: These are the Andes, Arnegard, Grail, Lawther, Lohler, Patent, Savage and Shambo series. Andes soils have mollic epipedons, lack B2 horizons, and have paralithic contacts at 20 to 40 inches depth. Arnegard and Grail soils have thick mollic epipedons and thick, dark colored noncalcareous sola. Lawther soils have mollic epipedons, and control sections that contain from 40 to 60 percent clay. Lohler and Patent soils have light color and lack B horizons. Savage soils have mollic epipedons and argillic horizons, and the sola are noncalcareous. Shambo soils have mollic epipedons and noncalcareous sola that contain more than 15 percent fine and coarser sand.

Setting: Cherry soils are on fans, footslopes, and terraces. The slope range is 2 to about 10 percent. The soil is formed in deep sediments washed from calcareous soft silty shales of mixed mineralogy. The climate is semiarid. Mean annual temperature ranges from 38 to 45 degrees F., and mean annual precipitation from 10 to 16 inches. Three-fourths of the rain falls in the spring and summer.

Principal Associated Soils: These are the competing Andes, Arnegard, Grail, and Patent soils and the Cabba, Chama, Morton and Sen soils. The Andes, Cabba, Chama, Morton, and Sen soils are on adjoining uplands at higher elevation and Arnegard and Grail soils in swales and flats. Cabba soils lack B horizons and have paralithic contacts at less than 20 inches depth. Chama and Sen soils have mollic epipedons, calcic horizons, and a paralithic contact at depths of less than 40 inches. Morton soils have

both mollic epipedons and argillic horizons.

Drainage and Permeability: Well drained. Runoff is moderate or moderately rapid. Permeability is moderate in the sola, and moderately slow or slow in the substrata.

Use and Vegetation: Cultivates areas used for growing grains and corn, hay and pasture in a crop-summer-fallow system. Native vegetation is western wheatgrass, blue grama, sideoats grama, little bluestem, and some forbs and shrubs.

Distribution and Extent: Western North Dakota, eastern Montana and northwestern South Dakota. The soil is of moderate extent.

Series Established: McKenzie County, North Dakota, 1932.

Remarks: The Cherry soils were classified as Brown soils in recently published Soil Surveys. The Cherry soils are not as dry as typical Aridisols and might better be placed in Inceptisols than Aridisols. The alternative placement is Typic Ustochrept.

EDGAR SERIES

The Edgar series comprises very thin solum Chestnut soils developed in deep, silty (poorly graded) materials. The usual profile sequence is a grayish brown silt loam A1 horizon, a brown prismatic silt loam B2 horizon, a prominent Cca horizon and a C horizon of silt loam texture. The Edgar series has a thinner solum (less than 10 inches) than the Gird series, becoming an Ap, Cca, C profile under cultivation. It lacks the textural B2 horizon and moderately thick solum of the Amsterdam series. It has a prominent Cca horizon; whereas the Joe Creek series has a weakly expressed or no ca horizon. The Edgar series has developed in parent materials containing less lime than the Chama series. It has more strongly expressed Cca horizons and is developed in more poorly graded materials than the Straw series. The Edgar series occurs under a mean annual precipitation of 11 to 16 inches, mean annual air temperature of 44 to 47 degrees F., and frost-free period of 95 or more days. It is moderately extensive and is important in agriculture.

Soil Profile: Edgar loam, grassland, 6% slope

A1 - 0-2" Grayish brown (10YR 5/2) silt loam; 10YR 3/2 when moist; weak medium platy structure; soft, very friable, slightly sticky and slightly plastic. Clear boundary. (1 to 3 inches thick)

A12 - 2-6"	Dark grayish (10YR 4/2) loam; 10YR 3/2 when moist; weak medium prismatic structure; slightly hard, very friable. Clear boundary. A1 is 3 to 5 inches thick.
B2 - 6-9"	Brown (10YR 5/3) silt loam; 10YR 3/3 when moist; moderate medium prismatic structure; slightly hard, very friable; slightly sticky and slightly plastic; thin patchy clay films. Clear boundary. (2 to 4 inches thick)
C1ca 9-32"	Light gray (1Y 7/2) loam; 1Y 5/3 when moist; weak coarse prismatic to massive structure; slightly hard, very friable; very strongly calcareous containing a few nodules of segregated lime. Gradual boundary. (16 to 24 inches thick)
C2 - 32-60"	Light yellowish brown (2.5Y 6/3) loam; 2.5Y 5/3 when moist; massive structure; soft, very friable, calcareous. (18 or more inches thick)

Range in Characteristics: Loam, silt loam, and very fine sandy loam types are recognized. The A horizon has color values of 5 or less dry and 3 or less moist with chroma of 2 or 3. The B2 horizon has colors with values of 4 or 5 dry and chroma of 2 to 4. Hues are 2.5Y to 7.5YR throughout. The Cca horizon has more distinct segregations of lime in some profiles. The solum and the parent materials contain more than 50 percent silt or silty very fine sand, 15 to 25 percent clay, and less than 10 percent of particle sizes coarser than very fine sand. The B2 horizon has less than 3 to 5 percent more clay than in A1 or Ap horizon. The noncalcereous solum ranges from 6 to 12 inches in thickness. Under moderate depths of tillage, all or nearly all the solum is incorporated into an Ap horizon; however, very thin remnants of a B2 horizon may be present. In cultivated fields, the usual horizon sequence is Ap, Cca, and C. A thin (3 to 5 inches) B3ca horizon is present in some profiles. A contrasting substratum of bedrock gravels, or other materials may be present below 40 inches. Colors are of dry soil unless otherwise stated.

Topography: Nearly level to sloping terraces and fans or mantle uplands.

Drainage and Permeability: Well drained. Subsoils have moderate permeability.

Vegetation: Prairie june, western wheat and blue grama grasses and dryland sedges.

Use: Principally for non-irrigated and irrigated cropland. Some

areas are still in range.

Distribution: Eastern plains of Montana.

Type Location: Yellowstone County, Montana, 330 feet north and 175 feet west of W quarter corner of Section1, T3S, R24E.

Series Proposed: Yellowstone County, Montana, 1952.

McRAE SERIES

The McRae series comprises Brown soils with very thin solums, developed in a thick regolith of loam texture. The usual horizon sequence under cultivation is a grayish brown noncalcareous or weakly calcareous loamy A horizon, a B2 horizon differing in color and structure but not in texture from the A horizon, a weakly expressed C1ca horizon with seams or a few nodules of lime, and a C2 horizon of stratified alluvium. The McRae series differs from the Havre series in having a horizon of segregated or accumulated lime. It has developed in well graded loam low in lime, whereas the Chama soils are developed in silt loam having a high $CaCO_3$ equivalent. The McRae soils are coarser in texture than the Cherry series. The McRae series is of moderate extent and importance to agriculture.

Soil Profile: McRae loam

Ap - 0-5"	Grayish brown (2.5Y 5/2) loam, very dark grayish brown (2.5Y 3/2) moist; moderate medium and thick platy structure; slightly hard, very friable; abrupt boundary. (5 to 10 inches thick)
B2 - 5-7"	Dark grayish brown (2.5Y 4/2) loam; very dark grayish brown (2.5Y 3/2) moist; color when crushed is one unit higher in chroma; moderate medium prismatic structure; hard, very friable, slightly sticky, slightly plastic; thin clay films; clear boundary. (0 to 5 inches thick)
B3 - 7-9"	Grayish brown (2.5Y 5/2) loam; dark grayish brown (2.5Y 4/2) moist; color when crushed is of 5Y hue but one unit higher in chroma; moderate medium prismatic structure; hard, very friable, slightly sticky, slightly plastic; clear boundary. (0 to 5 inches thick)
C1ca - 9-34"	Pale olive (5Y 6/3) loam; olive (5Y 5/3) moist; very weak coarse prismatic structure; becoming massive and stratified in lower part; hard, very friable, slightly sticky, slightly plastic; moderately

calcareous with few seams and nodules of lime; gradual boundary. (20 to 30 inches thick)

C2 - 34-60" Pale olive (5Y 6/3) loam; olive (5Y 5/3) moist; stratified with a few thin lenses of fine and very sandy loam; calcareous.

Range in Characteristics: Loam is the dominant type. The Ap horizon may be noncalcareous or weakly calcareous and has color values of 5 or more dry and 3 or more moist. The B2 horizon, where present, has moderate to strong prismatic structure and values of 5 or less and may be a heavy loam. The combined thickness of A1 and B2 horizons seldom exceeds 9 inches. Under deep cultivation, the A1 and B2 horizons are incorporated into the Ap horizon, giving an Ap, Cca, and C horizon sequence. Profiles may be free of carbonates to depths of 12 to 15 inches. The B2 horizon may be calcareous on some of the fans or footslopes below the steeper uplands. Colors are for dry soil unless otherwise stated.

Topography: Nearly level to sloping fans, terraces, footslopes.

Drainage and Permeability: Well drained. Subsoil permeability is moderate.

Vegetation: Mixed short and mid grasses, and forbs.

Use: Principally for both irrigated and nonirrigated cropland.

Distribution: Eastern Montana.

Type Location: Yellowstone County, Montana; 1350 feet south and 330 feet east of W¼ corner, Section 19, T4N, R33E.

Series Established: Treasure County, Montana, 1961.

MARIAS SERIES

The Marias series is a member of a mixed frigid family of Entic Chromusterts. The classification is tentative and subject to change. These soils have light colors, but have a very thin, moderately dark colored A1 horizon with enumerable fine tongues of this dark soil extending in hexogonal patterns around very coarse prisms to depths as great as 30 inches. The upper soil has strong granular and fine blocky structure and there are pressure faces on larger blocks in the subsoil. The soils have ochric epipedons and lack diagnostic subsurface horizons.

Typifying Pedons: Marias clay, cultivated
(Colors are for dry conditions unless otherwise noted.)

Ap - 0-6" Grayish brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) moist; strong very fine granular structure; granules hard and friable, sticky and very plastic; crust on surface 1/32 inch thick formed after hard rain, consists of adhering granules; slightly calcareous; abrupt boundary of cultivation.

A12 - 6-11" Grayish brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) moist; structure of strong coarse blocks easily separated to moderate very fine angular blocks; very hard, firm, sticky and very plastic; flat faces of blocks have glossy appearance; tongues of dark grayish brown soil (2.5Y 4/2) 1/8 to 1/2 inch thick form fine geometric patterns on the horizontal surface just below the plow layer; slightly calcareous; gradual boundary.

A13 - 11-27" Grayish brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) moist; structure of strong coarse blocks easily separated to moderate very fine angular blocks; very hard, firm, sticky and very plastic; slickensides with intersecting surface 20 to 40 degrees from horizontal are common and have surfaces 6 to 10 inches in diameter observed in moist soil; slightly calcareous; clear smooth boundary. (18 to 34 inches thick)

C1cs - 27-48" Gray (5Y 5/1) clay, very dark gray (5Y 3/1) moist; structure of moderate very coarse prisms easily separating to moderate very fine granules; very hard, firm, sticky and very plastic; thick large patches of organically stained clay films on some prism faces; many 1-inch diameter clusters and branching fine lines of gypsum crystals; slightly calcareous; gradual boundary.

C2cs - 48-74" Gray (5Y 5/1) clay, very dark gray (5Y 3/1) moist; structure of moderate very coarse prisms in which gray and light gray (5Y 5/1 and 7/1) very fine granules are distinct but held firmly in place; very hard, firm, sticky and very plastic; thick large patches of organically darkened clay films on some prism faces; many one-inch diameter clusters and 1/8 inch seams of gypsum crystals; slightly calcareous.

Type Location: Valley County, Montana, 6 miles east of village of Saco; 1/10 miles east of approach, at S¼ corner and 120 feet north of road center, U.S. Highway No. 2, T31N, R35E, Section 7, S¼ corner.

Range In Characteristics: Clay is the dominant type of the Marias series. Following hard rains on fallow ground, a thin (approximately ¼ inch) fragile crust forms that does not bear handling and in which

the form of the granules are distinct. Color of the All or Ap horizon has Munsell value of 5 or less dry and less than 3 moist. If an All horizon has Munsell values as low as 4 dry and 3 moist, it must be less than 3 inches thick. Where the All horizon is darker in color, it fills the spaces between prisms in tongues as thick as 3 inches below the All horizon, tapering out at depths as great as 30 inches. Color below the All horizon has Munsell values of 5 or more dry with chromas of 2 to 4 in hues yellower than 10YR. Percent organic carbon ranges from 1.5 to .5 in Ap horizon, and very gradually decreases below the Ap horizon to about .3 percent at depths of about 60 inches. Clay plus silt ranges from 80 to 98 percent in all horizons between depths of about 8 to 30 inches. Silt lamination may occur in the clay below 30 inches. Rounded and subangular stones, cobbles and gravel comprise up to 10 percent in total soil volume of upper soil horizons in glaciated areas of this soil. In these areas medium and coarser sands may comprise up to 10 percent of the soil less than 2 mm. in size. Clay in the subsoil horizons ranges from about 50 to 75 percent without more than 5 percent increase in clay over that in Al horizon of the clay or silty clay types. There may be a weak Cca horizon, but usually there is from 2 to 5 percent $CaCO_3$ equivalent distributed uniformly throughout the profile. Profiles are slightly or moderately saline below depths of about 20 inches. Exchangeable sodium percentage ranges between 3 and 5 percent in any horizon below 7 inches, but may be as high as 15 percent in horizons below about 30 inches.

Competing Series and Their Differentiae: There are no established series competing in the same family. The Promise soils have darker soil colors; the Pierre soils have moderate depths to shale bedrock. The Bew soils, classified as Mollic Normargids have distinct A, B and Cca horizonation.

Setting: Marias series occurs on upland plains or on valley terraces, developed in thick clay materials. These clay parent materials have high shrink-swell capacity. The climate is cool semiarid with mean annual soil temperature of 47 degrees F.; mean winter air temperature ranges from 18 to 28 degrees F. Mean annual precipitation ranges from 10 to 14 inches.

Principal Associated Soils: These include the Bew and Thebo in areas of light colored soils, and the Promise and Landusky soils in the region of darker colored soils. The Bew and Landusky soils have distinct A, B and Cca horizonation.

Drainage and Permeability: Well drained; surface runoff is medium; permeability is very slow in the wet soil and infiltration into the dry soil is medium to rapid.

Use and Vegetation: Used extensively in dryland and irrigated production of small grains. Native vegetation consists largely of

western wheatgrass and blue grama.

Distribution and Extent: Marias is a moderately extensive soil in eastern and central Montana, in northwestern South Dakota, eastern Wyoming and Colorado.

Series Established: Milk River area, Montana, 1928.

Remarks: The Marias series was formerly classified in the Grumusols soil group.

MIDWAY SERIES

The Midway series is a member of a clayey, montmorillonitic, calcareous, mesic, shallow family of Typic Torriorthents. Typically, these soils have light colored A and C horizons resting on beds of platy soft shale at depths shallower than 20 inches.

Typifying Pedon: Midway silty clay loam - virgin grass and brush (Colors are for dry condition unless otherwise noted.)

A1 - 0-3" Light yellowish brown (2.5Y 6/4) silty clay loam, light olive brown (2.5Y 5/4) moist; weak thin platy breaking to fine crumb structure; soft, friable, sticky and plastic; strongly calcareous; pH 8.4; gradual boundary; 2 to 8 inches thick.

AC - 3-7" Light yellowish brown (2.5Y 6/4) clay, light olive brown (2.5Y 5/4) moist; thin platy weathered shale; soft, friable, sticky and plastic; strongly calcareous; pH 8.0; abrupt boundary; 2 to 8 inches thick.

C - 7-14" Light brownish gray (2.5Y 6/3) mottled with light gray (2.5Y 7/2) clay, light olive brown (2.5Y 6/3) and olive (5Y 5/3) moist; thin platy weathered shale with gypsum crystals between the shale layers; strongly calcareous; pH 8.0; abrupt boundary; 2 to 8 inches thick.

R - 14-30" Pale olive (5Y 6/3) platy silty and clay shale, with seams of gypsum crystals; strongly calcareous; pH 8.4; mottled with yellows, browns and blacks.

Type Location: Powder River County, Montana, 300 feet south, 200 feet east of N¼ corner of Section 23, T3S, R49E.

Range in Characteristics: Midway soils are usually dry unless

irrigated and they are dry in all parts between depths of 3 inches and bedrock for 60 or more consecutive days. They have mean annual temperatures ranging from 47 to 50 degrees F. Clay loam and silty clay loam are dominant types of the Midway series. The A1 horizon has color values of 5 or 6 dry, 3 or 4 moist, chromas of 2 or 3, and hues of 2.5Y or 10YR. Texture of the A1 horizon and subsoil is clay loam with from about 35 to 45 percent clay, 20 to 50 percent silt, and less than an estimated 10 percent sands coarser than fine sand. Stratified shale beds occur at depths ranging from 6 to 20 inches. These may be of hard or soft consistency.

Competing Series and Their Differentiae: These include the Chipeta and Lismas series in the same family and the Elso series in a different family of the same subgroup. The Chipeta and Midway soils occur in different geographic areas. The Lismas soils have finer textures (more than 45 percent clay) developed in more clayey shale, whereas the Elso soils have less than 35 percent clay in profiles developed over loam or silt loam textured shales.

Setting: The Midway soils occupy convex slopes on crests of ridges and hills in shale bedrock uplands. Parent material is calcareous residium from calcareous platy soft shale in which clay is mostly of montmorillonitic mineral type. The climate is semi-arid to arid with mean annual precipitation ranging from 8 to 16 inches and a mean annual temperature of 45 to 48 degrees F.

Principal Associated Soils: These include Elso, Bainville, Lismas, Travessilla, Ocean Lake, Razor, Renohill, and Thurlow series. The Razor, Renohill and Thurlow series have heavy clay loam or clay textured B horizons.

Drainage and Permeability: Excessive; runoff is medium to rapid; internal drainage is slow.

Use and Vegetation: Principally native range with associations of short grasses or forbs - prairie junegrass, silver sage, thread-leaf sedge, western wheatgrass and rabbitbrush.

Distribution and Extent: Extensive in southeastern Montana.

Series Established: Central Montana Reconnaissance, 1943.

Remarks: The Midway series was formerly classified with the Lithosols soil group.

HAVRE SERIES

The Havre series is a member of the fine-loamy, mixed, calcareous, mesic family of Ustic Torrifluvents. Typically these light colored

calcareous soils lack horizonation and are developed in loam or light clay loam alluvium that may be stratified.

Typifying Pedon: Havre loam - stubble of irrigated small grain (Colors are for dry soil unless otherwise noted.)

Ap - 0-7" Light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak granular structure; soft, very friable, slightly sticky and slightly plastic; moderate effervescence, moderately alkaline (pH 8.4). (7 to 10 inches thick)

C1 - 7-31" Light brownish gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) moist; massive but with evident stratification varying slightly in color and amount of silt and sand in loam; slightly hard, friable, slightly sticky and slightly plastic; moderate effervescence, moderately alkaline (pH 8.4); clear boundary. (20 to 60 inches thick)

C2 - 31-58" Light gray (2.5Y 7/2) sandy loam, grayish brown (2.5Y 5/2) moist; massive; soft, very friable, nonsticky and nonplastic; moderate effervescence, moderately alkaline (pH 8.1); clear boundary. (0 to 30 inches thick)

IIC3 - 58-68" Light gray (2.5Y 7/2) sand and gravel; single grain; loose; slight effervescence.

Type Location: Yellowstone County, Montana; Yellowstone River Valley; T4N, R32E, 1,000 feet east of center of Section 6.

Range in Characteristics: Havre soils are usually dry between depths of 4 and 12 inches when soil temperature at 20 inches is warmer than 41 degrees F. but they are not dry in all parts above 12 inches during this period for more than half the time. They have mean annual soil temperature of 47 degrees F. or more. The profile may be noncalcareous in surface layers. It ranges from nonsaline to strongly saline and substrata layers may have more than 15 percent exchangeable sodium. Hues range from 5Y to 7.5YR. The surface layer usually has values greater than 5.5 dry and 3.5 moist but values of 5 dry and 3 moist may occur in an A1 horizon less than 6 inches thick. Chromas through the profile range from 1 through 3. The texture below the Ap horizon is loam or light clay loam with between 18 and 35 percent clay and more than 15 percent fine and coarser sand. The profiles are nongravelly. Buried A1 horizons are common.

Competing Series and Their Differentiae: These include the Hysham, Glendive, Lohmiller and Manvel series. The Hysham soils have a hard or very hard and massive surface, very strongly alkaline

reaction and more than 15 percent exchangeable sodium in the surface and subsoil layers. The Glendive soils have sandy loam between depths of 10 and 40 inches. The Lohmiller soils have clay loam between depths of 10 and 40 inches. The Manvel soils have silt loam between depths of 10 and 40 inches and have a regular decrease in amount of organic matter with increased depth and have a fine-carbonatic mineralogy.

Setting: The Havre soils occur on the flood plains of rivers and streams, on alluvial fans and on footslopes in the uplands in a semiarid climate. Parent materials are of mixed mineralogy, are of loam and light clay loam texture and are calcareous. The average annual precipitation ranges from 10 to 14 inches. The mean annual air temperature ranges from 45 to 50 degrees F.

Principal Associated Soils: Glendive and Lohmiller soils are the principal associated soils in valley flood plains with Fort Collins on river and stream terraces and Cushman, Bainville and Elso soils on the adjacent uplands. The Fort Collins and Cushman soils have B horizons. The Bainville and Elso soils have paralithic contact at respective depths of between 20 and 40 inches for Bainville and at less than 20 inches for Elso soils.

Drainage and Permeability: Havre soils are well drained and have moderate permeability. They are occasionally flooded for short periods during ice jams or exceedingly high runoff.

Use and Vegetation: Havre soils are used extensively in the irrigated production of alfalfa, small grains, sugar beets and potatoes. They are used inextensively for native grass range in narrow valleys of streams. Native vegetation is needle and thread, blue grama, western wheatgrass, with shrubs and trees on stream banks.

Distribution and Extent: The Havre series is extensive throughout central and southeastern Montana.

Series Established: Milk River area, Montana, 1928.

Remarks: The Havre series was formerly classified with the Alluvial soils great soil group.

LOHMILLER SERIES

The Lohmiller series is a member of a fine, montmorillonitic, calcareous, mesic family of Ustic Torrifluvents. Typically these light colored soils lack horizonation and are developed in silty clay loam and silty clay alluvium that may be stratified.

Typifying Pedon: Lohmiller clay loam - cultivated
(Color is for dry soil unless otherwise noted.)

Ap - 0-8" Light olive gray (5Y 6/2) clay loam, olive gray (5Y 4/2) moist; moderate medium granular structure; very hard, friable, sticky and plastic; strong effervescence; abrupt boundary.

C - 8-60" Light olive gray (5Y 6/2) clay loam, olive gray (5Y 4/2) moist; massive; very hard, friable, sticky and plastic; strong effervescence. (32 or more inches thick)

Type Location: Treasure County, Montana; 400 feet south and 50 feet west of east quarter corner; Section 27, T5N, R34E.

Range in Characteristics: The Lohmiller soils are usually dry between depths of 4 and 12 inches when soil temperature at 20 inches is warmer than 41 degrees F. but they are not dry in all parts above 12 inches more than half the time during this period. The mean annual temperature ranges from 48 to 50 degrees F. They are calcareous without or with only about 1 percent of segregated lime. They are moderately to strongly alkaline and they may be strongly saline but lack a salic horizon. Soil colors are in hues of 5Y to 10YR. There may be an A1 horizon with dry value of 5 and moist value of 3 as thick as 5 inches. Soil colors are more than 5.5 dry and more than 3.5 moist with chroma of 2 or 3. Soil between 10 and 40 inches is usually stratified with textures of loam and light clay or silt loam and silty clay, or may be of uniform texture. Average clay percentage in the 10 to 40-inch depth ranges from 35 to 45.

Competing Series and Their Differentiae: These include the Havre series in the same subgroup and the Heldt series in a different order. The Havre soils differ in having less than 35 percent clay in their 10 to 40-inch control section. The Heldt soils differ in having a cambic horizon. The Bowdoin soils differ in having more than 60 percent clay and in having mean annual soil temperature colder than 47 degrees F.

Setting: Lohmiller soils occur on the flood plains of rivers and streams on alluvial fans and on footslopes in the uplands in a semiarid and arid climate. Parent material is calcareous alluvium primarily from sedimentary rock sources. The clay minerals are predominantly montmorillonitic. The average annual precipitation ranges from 8 to 14 inches. The mean annual temperature ranges from 45 to 50 degrees F.

Principal Associated Soils: Havre, Heldt and Ulm are the principal associated soils in valleys, with Renohill, Razor or Midway soils on the adjacent uplands. The Renohill and Ulm soils have argillic horizons.

Drainage and Permeability: Lohmiller soils are well drained and they have moderately slow permeability and slow to medium rate of surface runoff.

Use and Vegetation: Lohmiller soils are used extensively for irrigated crop production of small grains, sugar beets, corn and alfalfa. They are also used for range of western wheatgrass, blue grama, dryland sedges and silver sage.

Distribution and Extent: The Lohmiller series is extensive in southeastern Montana.

Series Established: Treasure County, Montana, 1961.

Remarks: The Lohmiller series was formerly classified with Alluvial soils group.

NIHILL SERIES

The Nihill series comprises Typic Haplorthents, members of a loamy skeletal, mixed, calcareous, frigid family. These very gravelly soils are light colored and calcareous with a very thin, moderately dark colored A1 horizon and having accumulated lime as coatings on gravel throughout most of the five-foot profile.

Typifying Soil Profile: Nihill gravelly loam - native grass cover (Colors for dry conditions unless otherwise noted.)

A11 - 0-2½" Dark grayish brown (10YR 4/2) gravelly loam, very dark grayish brown (10YR 3/2) moist; weak fine crumb structure; soft, very friable, nonsticky and slightly plastic; calcareous; clear lower boundary. (2 to 4 inches thick)

A12 - 2½-7" Pale brown (10YR 6/3) gravelly loam dark grayish brown (10YR 4/3) moist, soft, very friable, nonsticky and slightly plastic; strongly calcareous with some lime coating on undersides of gravel; clear wavy boundary. (2 to 10 inches thick)

C1ca 7-29" Light brownish gray (2.5Y 6/2) very gravelly sandy loam; massive structure; slightly hard, very friable, nonsticky and nonplastic; strongly calcareous with distinct lime coatings on undersides of gravel; diffused boundary. (5 to 30 inches thick)

IIC2ca 29-60" Light brownish gray (2.5Y 6/2) very gravelly loamy coarse sand, light olive brown (2.5Y 5/3) moist;

single grain structure; loose consistence; strongly calcareous with distinct lime coating undersides of gravel

Type of Location: Wheatland County, Montana. One-fourth mile south 100 feet west of NE corner, Section 23, T8N, R15E, in cut along highway.

Range in Characteristics: Gravelly loam and very gravelly loam are dominant types in the Nihill series. The A horizon ranges in value from 5 to 6, chroma of 2 or 3 in 7.5YR or yellower hue. Color below the A horizon ranges in value of 6 to 7, chroma of 2 to 4, in 7.5YR or yellower hues. Texture below the A horizon ranges from very gravelly sandy loam to very gravelly light clay loam. Visible segregated lime ranges from distinct to very thin coatings on undersides of gravel with estimated percent of $CaCO_3$ ranging from 2 to 8. Content of gravel ranges from 50 to 70 percent. Depth to loamy sand or sand texture ranges from 25 to 40 inches.

Competing Series and Their Differentiae: These include the Tinsley soils with their sandy skeletal textures, the Bitter soils with their mollic epipedons and the Crago soils with their calcic horizons.

Setting: Nihill soils occupy convex shapes of slopes ranging from 8 to 30 percent on the brows of hills, edges and sides of terraces and mesas and on valley sides of high old upland terraces and benches. Climate is cool semiarid with a mean annual precipitation of 8 to 14 inches, mean annual soil temperature of 47 degrees F. or colder and a mean summer soil temperature warmer than 60 degrees F.

Principal Associated Soils: The Tinsley, Musselshell and Wanetta soils are the principal associates of the Nihill series.

Drainage and Permeability: Excessive; runoff is moderately rapid; permeability is moderately rapid.

Use and Vegetation: Use is principally native range of short grass associations with blue grama, threadleaf sedge and phlox predominate.

Distribution and Extent: Nihill is an extensive soil in central and eastern Montana, but is inextensive in any one local area.

Series Established: Soil Survey of Treasure County, Montana, 1961. Nihill is the name of a town in Wheatland County, Montana.

Remarks: The Nihill series was formerly classified in the Regosol soil group.

SHOREY SERIES

The Shorey series is a member of a fine-carbonatic, mesic family of Mollic Calciorthide. Typically these soils have a thin, moderately dark colored, calcareous A1 horizon and a thick, light colored Cca horizon with white coatings of $CaCO_3$ surrounding gravel and cobble and white accumulated $CaCO_3$ disseminated through the soil.

Typifying Pedon: Shorey gravelly loam - native grass (Colors are for dry soil unless otherwise specified.)

A11 - 0-4" Grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; moderate medium crumb structure; slightly hard, friable, slightly sticky and slightly plastic; moderately calcareous; gradual boundary. (2 to 5 inches thick)

A11 - 4-7" Grayish-brown (10YR 5/2) loam, dark grayish-brown (10YR 4/2) moist and very dark grayish brown (10YR 3/2) coated moist; weak prismatic structure; hard, friable, slightly sticky and slightly plastic; moderately calcareous; clear wavy boundary. (2 to 5 inches thick)

C1ca - 7-13" Brown (10YR 5/3) gravelly loam, dark brown (10YR 4/3) moist; weak medium prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; strongly calcareous with lime crusts on gravel and a few coarse white mottles of lime; clear wavy boundary. (5 to 10 inches thick)

C2ca - 13-20" Light gray (10YR 7/2) becoming white in lower part (10YR 8/2) loam, pale brown becoming very pale brown in lower part (10YR 6/3, 7/3) moist; massive with numerous fine and very fine pores; hard, friable, slightly sticky and slightly plastic, very strongly calcareous with white lime coating gravels and disseminated through the soil; clear boundary. (10 to 30 inches thick)

C3 - 30-42" Light brownish gray (10YR 6/2) gravelly sandy clay loam, brown (10YR 5/3) moist; massive with many fine and very fine pores; slightly hard, friable, nonsticky and nonplastic; strongly calcareous; gradual wavy boundary.

C4 - 42-48" Very pale brown (10Yr 7/3) very fine sandy loam, brown (10YR 5/4) moist; massive with many fine and very fine pores; soft, friable, nonsticky and

nonplastic; gradual wavy boundary.

C5 - 48-64" Pale brown (10YR 6/3) loam, brown (10YR 5/4) moist; massive; hard, friable, slightly sticky and slightly plastic; strongly calcareous.

Type Location: Yellowstone County, Montana, 430 feet east of S¼ corner, Section 26, T1S, R24E.

Range in Characteristics: The Shorey soils are usually dry when not frozen, unless irrigated. Their mean annual temperature is warmer than 47 degrees F. Soil colors range in hues of 10YR to 2.5Y. The amount of gravel and/or cobbles in profile range from a few to 30 percent by volume. The A1 horizon ranges from 2 to 10 inches thick and is calcareous at least in its lower part. It has values of 5 or 6 dry and 3 or 4 moist with chroma of 2 or 3. There the dry color value is 5 and moist color value is 3, the thickness is 5 inches or less. The Cca horizon has values of 7 or more dry and 6 or more moist, and has an estimated $CaCO_3$ equivalent of 20 to 40 percent and has 10 to 30 percent more $CaCO_3$ than in underlying C horizons. Texture of the Cca horizon is dominated by the larger amount of $CaCO_3$, but percent of clay including clay sized $CaCO_3$ ranges from 20 to 35 percent. There is more than 15 percent of fine and coarser sands and fine gravel in the Cca and upper C horizons.

Competing Series and Their Differentiae: These include the Numa and Pultney series in the same family. The Numa soils under long time irrigation have nitrogen and phosphate enriched epipedons. The Pultney soils have bedrock substrata between depths of 20 and 40 inches. The Avalanche, Crago and Musselshell series in the same subgroup have colder soil temperatures. The Clapper series, also in the same subgroup and the Crago soils have more than 35 percent volume of coarse fragments between depths of 10 and 40 inches. The Judith series has a mollic epipedon resting on a calcic horizon and has mean annual soil temperatures colder than 47 degrees F.

Setting: Shorey soils occur on uplands and in valleys where they are developed in old calcareous alluvium containing sands, gravels and rocks of mixed mineral origin. The climate is cool semiarid with mean annual temperature of 45 to 50 degrees F. and mean annual precipitation of 8 to 14 inches.

Principal Associated Soils: Clapper is the principal associate of the Shorey series.

Drainage and Permeability: Well drained. Permeability of subsoil is moderate.

Distribution and Extent: The Shorey soils are inextensive, comprising an estimated 10,000 acres in southeastern Montana.

Series Proposed: Yellowstone County, Montana, 1966.

Remarks: Shorey series was formerly classified with the Caleisols group of soils. It has an echric epipedon and a calcic horizon.

STRAW SERIES

The Straw series is a member of a fine loamy, mixed, frigid family of Cumulic Haplustolls. The soil profile usually has A1, B2 and C horizons. There is a cumulic mollic epipedon.

Typifying Pedon: Straw clay loam - native grasses (Colors are for dry conditions unless otherwise noted.)

A1 - 0-9" Dark grayish brown (10YR 4/2) light clay loam, very dark brown (10YR 2/2) moist; weak medium fine crumb structure in upper few inches; weak medium prismatic below; slightly hard, friable, slightly sticky and slightly plastic; calcareous; clear boundary; 5 to 12 inches thick.

B - 9-25" Dark grayish brown (10YR 4/2) light clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium and coarse prismatic structure; thin patchy clay films; hard, friable, slightly sticky and slightly plastic; calcareous with lime segregated in threads; gradual boundary; 15 to 30 inches thick.

C2 - 25-60" Grayish brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) moist; with few fine faint mottlings of dark brown and dark reddish brown around root channels; massive with pores; slightly hard, friable, slightly sticky and slightly plastic; calcareous.

Type Location: Judith Basin County, Montana; 1320 feet south and 100 feet east of center of Section 26, T16N, R11E.

Range in Characteristics: Clay loam, loam and silt loam types are dominant in the series with maximum clay content of 35 percent and maximum silt plus very fine sand content of 50 percent in the profile from about 10 to 40 inches. The color of the A1 horizon has values of 5 to 3, chroma of 2 in 10YR and 2.5Y hues. Colors of the B and C horizons are yellower than 7.5YR and redder than 5Y with Munsell values of at least one unit greater than of the A1 or Ap horizon, and having value of 3 or less in the moist color

to depths of about 10 inches. Lime appears in few to many very thin films and threads. Buried dark layers are common as are thin strata of contrasting texture. Yellow, brown and gray mottlings may be common or abundant below about 30 inches.

Competing Series and Their Differentiae: These include Arnegard and Twin Creek series in the same family, Parshall series in the same subgroup, and Adel series in Cumulic Haplic Cryoborolls. Arnegard soils are noncalcareous in their mollic epipedon. Twin Creek soils are redder in color. Parshall soils have coarse loamy textures between depths of 10 and 40 inches. Adel soils are non-calcareous and have summer soil temperatures colder than 60 degrees F.

Setting: Straw soils occur on terraces of rivers and creeks and on alluvial fans in the Northern Great Plains and Northern Rocky Mountains. Their calcareous parent material is alluvium from a variety of rock sources. They occur at elevations ranging from 3000 to 5000 feet. The climate is cool semiarid with mean annual temperature colder than 45 degrees F. and mean summer temperatures warmer than 64 degrees F. Mean annual precipitation ranges from 12 to 16 inches.

Principal Associated Soils: These include Havre, Lohmiller and Glendive series on floodplains of rivers and creeks, and Farland, Martinsdale and Danvers on higher terraces. The Havre, Lohmiller and Glendive soils lack horizons other than Ap horizons. The Farland, Martinsdale and Danvers soils have argillic horizons beneath mollic epipedons.

Drainage and Permeability: Well drained with slow runoff and medium permeability.

Use and Vegetation: Used in dryland and irrigated production of small grains and hay and for native range. Grasses are western wheatgrass, blue grama, and prairie junegrass.

Distribution and Extent: Northern Great Plains and valleys in the eastern part of Northern Rocky Mountains. The Straw series is moderately extensive.

Series Established: Judith Basin area, 1960. Straw is the name of a town in Fergus County, Montana.

Remarks: Straw soils were formerly classified with the Chestnut great soil group.

TULLOCK SERIES

The Tullock series comprise light colored moderately sandy Lithosols developed in materials weathered from calcareous weakly to moderately consolidated sandstones. These soils have a thin fine sandy loam or loamy fine sand, light colored A1 horizon which grades through fine sand or loamy fine sand to sandstones. The plant roots usually do not penetrate much below the upper foot. The Tullock soils have thinner, lighter colored and usually coarser textured surface horizons and usually more consolidated bedrock than Flasher soils. They are often associated with the Bainville soils but are more sandy throughout. The Travessilla soils differ in having a much harder sandstone bedrock. Terry soils differ in having a fine sandy loam B2 horizon with clay films on peds. The Tullock series is extensive and moderately important agriculturally.

Soil Profile: Tullock fine sandy loam

A1 - 0-6" Light brownish gray (2.5Y 6/2) fine sandy loam, dark grayish brown (2.5Y 4/2) moist; weak fine granular structure; soft, very friable; mildly calcareous; clear boundary; 3 to 7 inches thick.

AC - 6-14" Light yellowish brown (2.5Y 6/3) heavy loamy fine sand, olive brown (2.5Y 4/3) moist; very weak coarse prismatic structure; soft, very friable; strongly calcareous; diffuse boundary; 4 to 10 inches thick.

C - 14-28" Pale yellow (2.5Y 7/3) loamy fine sand, light olive brown (2.5Y 5/3) moist; massive; slightly hard, very friable; strongly calcareous; few sandstone fragments in lower part; few plant roots; diffuse boundary; 3 to 20 inches thick.

R - 28-60" Soft sandstone which crushes rather easily to pale yellow (5Y 7/3) loamy fine sand, olive (5Y 5/3) moist; strongly calcareous; more consolidated and harder in the lower part; plant root scarce.

Range in Characteristics: The texture of the material above the bedrock ranges from fine sand to fine sandy loam with less than 15 percent clay. The depth to bedrock ranges from 10 to 30 inches, but plant roots are few to none below 14 inches, except as root penetration extends in cracks in the sandstone. Thin lenses of hard sandstone may be present in the bedrock. The surface may be calcareous in the undisturbed areas but are always calcareous in tilled fields. Color of the A horizon may range in hue from slightly redder than 10YR to slightly yellower than 2.5Y, in chroma from 1.5 to 3, and in value from 5 to 7 and 3 to 5 when

moist. If dark it should be less than 4 inches thick. Soil color names are for the dry soil unless otherwise stated.

Topography: Undulating to sharply rolling uplands.

Drainage and Permeability: Well drained. Surface runoff is slow. Subsoil permeability is rapid.

Vegetation: Needle and thread, blue grama, threadleaf sedge, and sand reedgrass and cactus.

Use: Primarily for native range. A few areas are used for small grains, particularly where associated with loamy upland soils.

Distribution: Eastern Montana, Wyoming and Colorado.

Type Location: Yellowstone County, Montana. About 700 feet west of center of NE¼, Section 33, T5N, R27E.

Series Established: Will be recommended for establishment by prior correlation in Yellowstone County, Montana.

VIDA SERIES

The Vida series is a member of the fine-loamy, mixed family of Typic Argiborolls. Typically Vida soils have dark grayish brown granular light clay loam Ap horizons and brown prismatic clay loam B2t horizons extending to nine inches. Segregated lime occurs in a light brownish gray clay loam Bca horizon resting on light gray clay loam C horizon.

Typifying Pedon: Vida clay loam - cultivated
(Colors are for dry soil unless otherwise noted.)

Ap - 0-5" Dark grayish brown (10YR 4/2) light clay loam, very dark grayish brown (10YR 3/2) moist; moderate fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; moderately alkaline (pH 8.0); clear boundary. (2 to 7 inches thick)

B2t - 5-9" Brown (10YR 4/3 clay loam, very dark grayish brown (10YR 3/2) moist; moderate coarse and medium prismatic and subangular blocky structure; hard, firm, sticky, plastic; common fine and medium roots and pores; moderately alkaline (pH 8.0); clear boundary. (2 to 7 inches thick)

B3ca - 9-22" Light brownish gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; moderate coarse prismatic

structure; hard, firm, sticky, plastic; common fine and few medium roots and pores; thin patchy clay film; few fine coal chips; many threads of lime; strongly calcareous (pH 8.4); gradual boundary. (12 to 15 inches thick)

C - 22-60" Light gray (2.5Y 7/2) clay loam, grayish brown (2.5Y 5/2) moist; weak coarse prismatic structure; hard, firm, sticky, plastic; few fine and medium roots; many coal chips and few shale fragments; strongly calcareous (pH8.8).

Type Location: Dawson County, Montana; T23N, R50E, Section 20, 1,050 feet south of NW corner of section.

Range in Characteristics: Vida soils have random distribution of clay, silt, sand, gravel and cobbles throughout the soil pedon and have from 5 to 20 percent gravels and cobbles. They are usually moist. They have mean annual soil temperature ranging from 44 to 47 degrees F. and their average summer soil temperature ranges from 60 to 65 degrees F. Thickness of the combined A1 and B2t horizons and depth to calcareous soil ranges from 6 to 10 inches. The A1 horizon ranges from loam to light clay loam with a maximum of 30 percent clay and a thickness ranging from 3 to 5 inches. Soil colors are in hues of 10YR to 2.5Y with values of 3 or 4 dry with chroma of 2. The B2t horizon is clay loam with from 27 to 35 percent clay. Soil colors range in hue from 10YR to 2.5Y with value of 4 to 6 dry with chroma of 2 to 4, with the upper part or all of the horizon comprising the lower part of the mollic epipedon. Segregated lime is in a prismatic structured B3ca horizon having organic stained coatings on prism faces or in a Cca horizon that has a weak corase prismatic structure. Texture of the C horizon is loam or light clay loam with from 22 to 30 percent clay and an estimated dry soil bulk density ranging from 1.6 to 1.8 grams per cc. Soil colors range from light brownish gray (10YR 6/2) to light gray (5Y 6/1).

Competing Series and Their Differentiae: These include the Adiv, Daniels, Dooley, Doughty, Farnuf, Lefor, Livona, Martinsdale, McCabe, Reeder, Roundley, Sipple, Telstad, Tschicoma, Watrous, Wemple, Williams and Yegen series. Adiv soils have bulk density of about 1.5 in their C horizons. Roundley soils have paralithic contact at about 34 inches. Williams soils have combined thickness of A1 and B2t horizons and depth to calcareous soil ranging from 10 to 24 inches. All other competing series have solum thickness and depth to calcareous soil greater than 10 inches. In addition, the Telstad soils have dry soil color value of A1 or Ap ranging from 5 to 5.5.

Setting: Glaciated plains of northeastern Montana and northwestern North Dakota where the soils are developed in calcareous

glacial till of mixed mineral composition. Vida soils are developed under grass in a moist-semiarid climate of 13 to 16 inches average annual precipitation, mean annual temperature ranging from 40 to 45 degrees F., average summer temperature ranging from 63 to 67 degrees F. and average winter temperature ranging from 10 to 20 degrees F. The average frost-free season ranges from 90 to 110 days.

Principal Associated Soils: These are the Arnegard, Niobell, Noonan, Williams, Zahill and Zahl series. The Arengard soils have mollic epipedons more than 20 inches thick. Niobell and Noonan soils have natric horizons. Vida, Williams and Zahill soils occur in complex associations in many places. Zahill and Zahl soils lack B horizons and the Zahill soils have ochric epipedons.

Drainage and Permeability: Well drained; moderate permeability; slow to medium runoff and medium infiltration.

Use and Vegetation: Used principally for dryland production of small grains. Native vegetation consists of associations of mid and short grasses.

Distribution and Extent: Vida soils occur on the glaciated plains of northeastern Montana and northwestern North Dakota where it is moderately extensive.

Series Proposed: Dawson County, Montana, 1970. The name is of a post office in McCone County, Montana, where the series was first described.

Remarks: Vida soils formerly were classified with Chestnut soils.

WOLF POINT SERIES

The Wolf Point series is a member of the fine, montmorillonitic, calcareous, frigid family of Ustertic Torrifluvents. These soils have grayish brown, granular, silty clay, A horizons and silty clay C horizons with wide cracks.

Typifying Pedon: Wolf Point silty clay - cultivated
(Colors are for dry soil unless otherwise noted.)

Ap - 0-6" Olive gray (5Y 5/2) rubbed, gray (5Y 5/1) unrubbed, heavy silty clay, olive gray (5Y 4/2), rubbed, very dark gray (5Y 3/1) unrubbed, moist; strong fine and very fine granular structure; very hard, friable, sticky and very plastic; weak effervescence; cracks are 1 to 3 inches wide and 8 to 18 inches apart; abrupt wavy boundary. (6 to 10 inches thick)

AC - 6-10" Olive gray (5Y 5/2) rubbed, gray (5Y 5/1) unrubbed, heavy silty clay, olive gray (5Y 4/2) rubbed, very dark gray (5Y 3/1) unrubbed, moist; strong very fine blocky structure separating to strong fine granules; extremely hard, firm, sticky and very plastic; weak effervescence; 1 to 2 inch wide cracks; diffuse boundary.

C1 - 10-24" Olive gray (5Y 5/2) heavy silty clay, dark grayish brown (2.5Y 4/2) moist; moderate fine blocky structure; extremely hard, firm, sticky and very plastic; stress or pressure cutans on surface of structural aggregates; ½ to 1 inch wide cracks; weak effervescence; diffuse boundary.

C2 - 24-42" Olive gray (5Y 4/2) heavy silty clay, olive gray (5Y 4/2) moist; weak blocky structure in upper part and massive in lower part; extremely hard, firm, sticky and very plastic; some stress or pressure cutans on surface of structural aggregates and on vertical surfaces of 1/4 to 1/3 inch cracks; an occasional thin lens of heavy silty clay loam up to 2 inches thick; weak effervescence; diffuse boundary.

C3 - 42-60" Light olive gray (5Y 6/2) heavy silty clay, olive gray (5Y 4/2) moist; massive; extremely hard, firm, sticky and plastic; lenses of silty clay loam and light silty clay up to 2 inches thick and lenses of loam and silt loam less than 1 inch thick; few fine faint light yellowish brown (2.5Y 6/3 and 6/4) dry, mottles; weak effervescence.

Type Location: Roosevelt County, Montana; T27N, R46E; 700 feet west and 50 feet north of center of Section 6.

Range in Characteristics: The control section is silty clay or clay with a weighted average of about 52 percent clay but with a range from 46 to 60 percent clay, 40 to 50 percent silt plus very fine sand and 0 to 10 percent fine and coarser sand. Montmorillonite or expanding mixed with moderate amounts of montmorillonite is the dominant clay type have a CEC of 60 to 70 me/100 gm clay. The mean annual temperature is about 44 degrees F. but has a range of 42 to 47 degrees F. These soils are usually dry. The epipedon has moderate to strong grades of granular structure and has colors in 5Y or 2.5Y hue with values of 5 or 6 dry and 4 moist and with chroma of 1 or 2. The subsoils have massive or blocky (fragmental) structural aggregates and have weak to moderate effervescence. Occational lenses up to 2 inches thick of coarser textured materials occur in some pedons at any depth below 24 inches, and contrasting materials occur between depths of 40 and 60 inches as phases. Seeped and saline phases also occur.

Competing Series and Their Differentiae: These include the Bowdoin, Cashel, Harlem, Hattie, Lawther, Lohler, Lohmiller, Magnus, Marias, Marvan, Nashua, Pendroy, Strater, and Survant series. The Bowdoin soils have more than 60 percent clay in their control sections. The Cashel, Hattie, Lawther, and Magnus soils have mollic epipedons. The Harlem, Lohler, and Lohmiller soils have less than 46 percent clay in their control sections. The Marias, Marvan and Pendroy soils have a regular decrease in organic carbon. The Nashua, Strater and Survant soils have loam materials in the lower part of their control sections.

Setting: The Wolf Point soils are on level flood plains and low terraces in the valleys of live or intermittent streams. The regolith consists of deep, calcareous, clay alluvium. The climate is cool, dry-semiarid, with long, cold, dry winters and moist springs and summers. The mean annual precipitation is 10 to 14 inches, more than 70 percent of which falls when soil temperature at 20 inches is above 41 degrees F. The mean annual temperature is 40 to 45 degrees F., mean January temperature 10 to 25 degrees F., and mean July temperature 65 to 72 degrees F. The frost-free period is 105 to 135 days.

Principal Associated Soils: These are the Bowdoin, Gesa, Harlem, Nashua, Strater and Survant series. The Gesa soils have a high water table and a salic horizon.

Drainage and Permeability: Well and moderately well drained with slow runoff and moderate to slow infiltration. Permeability is slow to very slow.

Use and Vegetation: These soils are used for growing nonirrigated small grains and corn and irrigated small grains, corn, sugar beets, and alfalfa. The native vegetation is western wheatgrass and big sagebrush.

Distribution and Extent: The Wolf Point series is widely distributed in the valleys of the eastern plains of Montana and possibly in adjacent states. It is of moderate extent.

Series Proposed: Detailed soil survey of Roosevelt County, Montana, 1952. This is a place name.

Remarks: The Wolf Point series was formerly classified with the Alluvial soils.